CERTIFICATE

I, Yasushi KOEDUKA of 4-16-3-403, Kojidai, Nishi-Ku, Kobe-shi, Hyogo 651-2273 JAPAN hereby certify that to the best of my knowledge and belief the following is a true translation of the Japanese Patent Application No. 2002-338573.

Nov. 30, 2006 Yasushi Koeduka

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【TITLE OF THE INVENTION】 MEASURING UNIT, MOLD FOR MOLDING PARTITION MEMBER EMPLOYED IN MEASURING UNIT, AND PRODUCTION METHOD FOR PARTITION MEMBER

【CLAIMS】

【Claim 1】 A measuring unit comprising: a partition member having a through-hole through which a liquid is allowed to pass and a rib which projects from at least either of a front surface and a rear surface around the through-hole; a first member having a first channel; and a second member having a second channel; wherein the partition member is sandwiched liquid tightly between the first member and the second member so that the through-hole allows the first member being communicated with the second member, and the first member and the second member respectively has a first electrode and a second electrode for measuring electrical properties of liquid passing via the through-hole in the first channel and the second channel.

【Claim 2】 The measuring unit of claim 1, wherein one of the first and second members has a recess for receiving the partition member and the other has a projection which is fitted in a space surrounded by the rib of the partition member.

【Claim 3】 The measuring unit of claim 1, wherein the rib has a ring shape.

【Claim 4】 The measuring unit of claim 1, wherein the first channel, the second channel, and the through-hole are located coaxially.

【Claim 5】 The measuring unit of claim 1, wherein the partition

member has a recess comprising the through-hole.

【Claim 6】 A mold for use in injection molding of a partition member employed in the measuring unit of claim 1, the mold comprising: a male die comprising a core pin having a shape conformable to the through-hole; and a female die comprising a cavity having a shape conformable to the partition member; wherein the female die further comprises a vent for degassing located in opposed position to the core pin.

【Claim 7】 The mold of claim 6, wherein the vent has an inner diameter smaller than an outer diameter of the core pin.

【Claim 8】 The mold of claim 6, wherein the female die comprises a pin embedded in a center of the cavity, and the vent is provided in the pin.

【Claim 9】 A method for molding a partition member by the mold of claim 6, the method comprising the steps of: combining the male die and the female die; injecting a plasticated material into the cavity at a predetermined pressure; solidifying the molded material by cooling; and separating the male die and the female die, and unmolding the molded material.

【DETAILED DESCRIPTION OF THE INVENTION】

【0001】

【Field of the Invention】

The present invention relates to a measuring unit, mold for molding the partition member employed in the measuring unit, and production method for the partition member.

【0002】

【Related Art】

The following arts are known as related art relating to the present invention.

For example, patent document1 discloses a pellet for use in a particle detector to be incorporated in a particle counter of an electrical resistance type which is adapted to determine the number of particles in a particle suspension passing through a minute through-hole on the basis of a change in electrical characteristic occurring due to a difference in electrical impedance between the suspension and the particles. The pellet is produced by forming one or more minute through-holes in an electrically insulative plastic sheet or film by an excimer laser abrasion method, and has a predetermined shape around each of the minute through-holes.

【0003】

For example, patent document 2 discloses a unitary pellet which comprises an orifice provided in a center portion thereof, conical slant portions provided on opposite sides of the orifice coaxially with the orifice, and one or more reinforcement members provided between rear surfaces of the slant portions.

【0004】

【Patent document1】

Japanese Unexamined Patent Publication No. Hei 9-304265 (1997)

【Patent document2】

Japanese Unexamined Patent Publication No. Hei 11-281564 (1999)

【0005】

【Problems to be resolved by the Invention】

An electrical resistance method is known as a method for electrically detecting the number and volume of particles suspended in an electrically conductive liquid. In the electrical resistance method, a channel for the particle suspension is divided by a partition member (pellet) having a minute through-hole, and a change in electrical resistance occurring when the particles pass through the through-hole is detected.

The resistance change ΔR and the volume Vp of the particles have the following relationship:

$$\Delta R=(\rho_0/S^2)Vp \quad \ldots\ldots \quad (1)$$

whereinρ$_0$ is the electrical resistance of the liquid, and S is the cross sectional area of the minute through-hole. For accurate determination of the volume Vp of the particles on the basis of the expression (1), it is necessary to form the minute-hole in the partition member with higher levels of dimensional accuracy and reproducibility.

【0006】

Therefore, it is a conventional practice to employ artificial ruby or sapphire for the production of the partition member and achieve the formation of the minute through-hole by a laser machining process. However, the artificial ruby and sapphire are hard and, hence, not easy to machine.

Therefore, a partition member produced by employing a more

easy-to-machine and softer material than the aforesaid hard material and a partition member reinforced by additionally providing a structural component are under consideration. However, these partition members are insufficient in performance and, hence, make it difficult to provide satisfactory measurement results when employed for the measurement by the electrical resistance method.

【0007】

In view of the foregoing, the present invention provides a measuring unit which ensures accurate particle analysis employing a partition member produced by softer material, a mold for molding the partition member, and a production method for the partition member.

【0008】

【Means of solving the problems】

The present invention provides a measuring unit comprising: a partition member having a through-hole through which a liquid is allowed to pass and a rib which projects from at least either of a front surface and a rear surface around the through-hole; a first member having a first channel; and a second member having a second channel; wherein the partition member is sandwiched liquid tightly between the first member and the second member so that the through-hole allows the first member being communicated with the second member, and the first member and the second member respectively has a first electrode and a second electrode for measuring electrical properties in the first channel and the second channel.

【0009】

【Description of the Embodiment】

The characteristic of a measuring unit according to the present invention is that the measuring unit comprising: a partition member having a through-hole through which a liquid is allowed to pass and a rib which projects from at least either of a front surface and a rear surface around the through-hole; a first member having a first channel; and a second member having a second channel; wherein the partition member is sandwiched liquid tightly between the first member and the second member so that the through-hole allows the first member being communicated with the second member, and the first member and the second member respectively has a first electrode and a second electrode for measuring electrical properties in the first channel and the second channel.

【0010】

According to above-mentioned configuration, the partition member is molded so that it has a through-hole through which a liquid is allowed to pass and a rib which projects from at least either of a front surface and a rear surface around the through-hole. Therefore, it is possible to provide a partition member with higher levels of dimensional accuracy and reproducibility, and to provide a measuring unit which ensures accurate particle analysis because mechanical strength of the partition member is improved efficiently by the rib around the through-hole.

【0011】

In addition, it is preferred that at least either of a front surface and a rear surface in above-mentioned measuring unit has a recess for

receiving the partition member and the other has a projection which is fitted in a space surrounded by the rib of the partition member. This configuration improves the liquid tightness between the upper plate and the lower plate, and prevent liquid passing from the first channel to the second channel via the through-hole from leaking.

【0012】

The rib of the partition member may have a disk shape.

The partition member may be formed disk-shaped, and the rib may be formed ring-shaped on the front surface of the partition member concentrically with the throuth-hole.

Meanwhile, shape of the partition member is not limited to a disk shape, and may be elliptical and polygonal.

【0013】

In a different aspect, the present invention provides a mold for use in injection molding of a partition member employed in the above-mentioned measuring unit, the mold comprising: a male die comprising a core pin having a shape conformable to the through-hole; and a female die comprising a cavity having a shape conformable to the partition member; wherein the female die further comprises a vent for degassing located in opposed position to the core pin.

According to above-mentioned mold, the female die comprises the vent for degassing located in opposed position to the core pin. Therefore, a molding material is smoothly flowed into a position near the corepin and a through-hole of a partition member is formed with high accuracy by the corepin.

【0014】

It is preferred that the vent has an inner diameter smaller than an outer diameter of the core pin.

In this configuration, a difference of position between the corepin and the vent for degassing is prevented.

The female die may comprises a pin embedded in a center of the cavity, and the vent may be provided in the pin.

Further, in a different aspect, the present invention provides a method for molding a partition member by the above-mentioned mold, the method comprising the steps of: combining the male die and the female die; injecting a plasticated material into the cavity at a predetermined pressure; solidifying the molded material by cooling; and separating the male die and the female die, and unmolding the molded material.

According to this production method, it is possible to mass-produce a partition member with similarly dimension.

【0015】

EMBODIMENT

With reference to the attached drawings, the present invention will hereinafter be described in detail by way of an embodiment thereof. However, it should be understood that the invention be not limited to this embodiment.

【0016】

1. Construction of Unit Body

FIGS. 1 and 2 are a top plan view and a front view of a measuring

unit according to an embodiment of the invention. FIG. 3 is a perspective view illustrating the internal construction of the measuring unit.

【0017】

As shown in FIGS. 1 to 3, a unit body 1a includes an upper plate 2a and a lower plate 3a each composed of a transparent resin (e.g., an acryl resin or a polycarbonate resin containing an antistatic agent). The unit body 1a includes: an elongated sample receiving section 4a having a volume of 200 .mu.L for receiving a sample; a rotary valve 6a including a diluent container 5a incorporated therein, and having a sample metering function and a flow path switching function; an electrical resistance measuring section 7a; an optical characteristic measuring section 7b; and first, second and third pump connection ports 8a, 9a and 10a. The connection ports 8a, 9a, 10a are each constituted by pipes projecting upward and downward from the lower plate 3a as shown in FIG. 38. The pipes of the connection ports 8a, 9a, 10a projecting downward are respectively inserted into pump connection tubes, while the pipes of the connection ports 8a, 9a, 10a projecting upward prevent liquid in channels 12a, 14c, 15g from being sucked out through the connection ports 8a, 9a, 10a.

【0018】

The sample receiving section 4a has a sample injection port provided on the top thereof, and the bottom thereof is connected to the rotary valve 6a via a channel 11a. A capillary blood sampler 4b may be provided at the bottom of the sample receiving section 4a with a distal

end thereof inserted in the channel 11a as shown in FIG. 37. The pump connection port 8a is connected to the rotary valve 6a via the channel 12a. The electrical resistance measuring section 7a and the optical characteristic measuring section 7b are connected to the rotary valve 6a via a channel 13a, to the pump connection port 9a via the channel 14c, and to the pump connection port 10a via the channel 15g.

【0019】

As will be described later in detail, the channels 11a, 12a constitute a metering channel for introducing the sample to a sample metering section. The channel 13a constitutes a measuring channel for introducing a diluted sample from the diluent container 5a into the electrical resistance measuring section 7a and the optical characteristic measuring section 7b. Further, the channels 13a, 14c constitute an agitation channel for agitating a mixture of the metered sample and a diluent for preparation of the diluted sample. The channel 15g allows the electrical resistance measuring section 7a to communicate with the pump connection port 10a to constitute a retention channel for retaining the diluted sample introduced therein after measurement.

【0020】

As shown in FIGS. 3 and 38, the channel 14c is configured so that the sectional area thereof becomes greater toward the pump connection port 9a, and has a projection 14d provided on an interior surface thereof. With this arrangement, bubbles generated when the mixture of the metered sample and the diluent is moved back and forth in arrow directions A and B for agitation thereof (to be described later with

reference to FIG. 30) are prevented from flowing into the optical characteristic measuring section 7b (i.e., in the arrow direction A). Thus, occurrence of noises during measurement of an optical characteristic can be prevented.

【0021】

2. Construction of Rotary Valve

FIGS. 4, 5 and 6 are a top plan view, a front view and a bottom view, respectively, of the rotary valve 6a. As shown in FIGS. 4 to 6, the rotary valve 6a includes an outer cylinder 16a having an open bottom, and an inner cylinder 17a having a closed bottom and inserted in the outer cylinder 16a from the bottom of the outer cylinder 16a. The inner cylinder 17a has an open top, and a flange 18a provided at the bottom thereof. The outer cylinder 16a has a through-hole 37a formed in the center of the top thereof for opening the diluent container 5a to the atmosphere. The through-hole 37a is usually closed by a sealing member not shown, and opened when the unit body 1a is used.

【0022】

Two projections 19a, 20a project downward from the flange 18a to define a groove 21a having non-parallel edges therebetween. The projections 19a, 20a constitute a connector to be connected to a valve driving source to be described later. When the inner cylinder 17a is rotated about an axis thereof, an outer circumferential surface of the inner cylinder 17a is slidable in contact with an inner circumferential surface of the outer cylinder 16a. Although the groove 21a has the non-parallel edges in this embodiment, the groove 21a may have

parallel edges.

【0023】

FIGS. 7 and 8 are sectional views of the rotary valve 6a as seen in arrow directions A-A and B-B, respectively, in FIG. 5. FIG. 9 is a sectional view of the rotary valve 6a as seen in an arrow direction X-X in FIG. 4.

【0024】

As shown in FIG. 7, the inner cylinder 17a has three elongated lateral grooves 24a, 25a, 26a formed in circumferentially aligned relation in an upper portion of the outer circumferential surface thereof, and the outer cylinder 16a has three through-holes 27a, 28a and 29a communicating with the channels 11a, 12a and 13a, respectively.

As will be described later, the lateral groove 25a serves as the sample metering section, and the lateral grooves 24a, 26a serve as channel opening and closing grooves.

【0025】

As shown in FIG. 8, the inner cylinder 17a has two through-holes 30a, 31a formed in a lower portion thereof for channel opening and closing. As shown in FIGS. 7 to 9, the outer cylinder 16a further has an elongated vertical groove 32a formed in the inner circumferential surface thereof as extending axially from an upper portion to a lower portion thereof.

As shown in FIG. 9, the inner cylinder 17a has an inwardly projecting conical bottom, which improves the efficiency of mixing the blood sample with the diluent in the inner cylinder 17a and makes it possible

to completely discharge the sample. Alternatively, the inner cylinder 17a may have a cylindrical projection provided in the center portion of the bottom thereof as shown in FIG. 11. As shown in FIGS. 9 and 11, the outer peripheral edge of the flange 18a projects upward in a ring shape. With this arrangement, liquid which happens to leak through the side face of the inner cylinder 17a is retained in the flange 18a. A gap is defined between parts of the outer cylinder 16a and the inner cylinder 17a. This alleviates a load exerted on a stepping motor 105a during the rotation of the inner cylinder 17a.

【0026】

3. Construction of Electrical Resistance Measuring Section

As shown in FIGS. 1 and 3, the electrical resistance measuring section 7a includes a disk-shaped partition member (pellet) 33b provided between vertical portions 15d and 15e of an internal channel 15f thereof, an electrode 34a provided in a junction between the channels 15g and 15f with a distal end thereof exposed to the inside of the channel, and an electrode 35a provided in a junction 36a between the channels 13a and 14c with a distal end thereof exposed to the inside of the channel.

【0027】

FIG. 10 is a sectional view illustrating a major portion of the electrical resistance measuring section 7a. The pellet 33b is fitted in a round recess formed in the lower plate 3a coaxially with the vertical portion 15e and pressed by a round projection provided on the upper plate 2a coaxially with the vertical portion 15d.

【0028】

The pellet 33b has a minute through-hole 33c formed in the center thereof, so that the electrical resistance of an electrolytic solution passing through the minute through-hole 33c is measured by the electrodes 34a, 35a.

As shown in FIG. 10, a plurality of grooves V are formed in an upper wall surface (ceiling surface) of the channel 15f as extending parallel to each other longitudinally of the channel 15f. With this arrangement, bubbles in the electrolytic solution flowing through the minute through-hole 33c in the channel 15f are trapped by the grooves V, and the electrolytic solution is rectified for stabilization of the flow thereof. This suppresses noises in measurements obtained by means of the electrodes 34a, 35a.

4. Construction of Optical Characteristic Measuring Section

As shown in FIG. 1, the optical characteristic measuring section 7b is located in the vicinity of the pump connection port 9a of the channel 14c. In the optical characteristic measuring section 7b, the channel 14c is configured so that a light emitting diode 125 and a photodiode 126 of the analyzer (to be described later) can be provided on upper and lower sides of the channel 14c as shown in FIG. 38 for measurement of the intensity of light transmitted through liquid present in the channel 14c.

【0029】

5. Analyzer

FIG. 12 is a block diagram illustrating the construction of an analyzer 100a which analyzes white blood cells and hemoglobin in a

blood sample with the use of the unit body 1a. A constant direct current source 101a of the analyzer 100 is connected to the electrodes 34a, 35a of the unit body 1a, and electric syringe pumps 102a, 103a and 104a are connected to the first, second and third pump connection ports 8a, 9a and 10a, respectively. A stepping motor 105a for driving the valve 6a is detachably connected to the valve 6a via a connector (not shown) engaged with the groove 21a formed in the flange 18a at the bottom of the valve 6a.

【0030】

A signal processing section 106e includes a controlling section 106c and a computing section 106d, which are comprised of a microprocessor. The controlling section 106c drives the electric syringe pumps 102a, 103a, 104a, the stepping motor 105a and the light emitting diode 125 in response of a command applied thereto from an input section 107a. The computing section 106d counts the number of the white blood cells and calculates the size of each of the white blood cells on the basis of signals applied from the electrodes 34a, 35a. Further, the computing section 106d calculates the amount of the hemoglobin on the basis of signals from the photodiode 126. The results of the calculations are displayed on a display section 108a.

The analyzer 100a further includes an input/output port (interface) 109 for interfacing the signal processing section 106e with an external computer and printer for signal reception and transmission.

【0031】

6. Measuring operation

With reference to flow charts shown in FIGS. 13 to 15, an explanation will hereinafter be given to the operation of the analyzer 100a shown in FIG. 12. FIGS. 16(a), 16(b), 17(a), 17(b), 18(a), 18(b), 19(a), 19(b), 20(a) and 20(b) illustrate rotational positions of the inner cylinder 17a with respect to the outer cylinder 16a of the rotary valve 6a. Particularly, FIGS. 16(a) to 20(a) and FIGS. 16(b) to 20(b) are sectional views of the rotary valve 6a as seen in arrow directions A-A and B-B, respectively, in FIG. 5.

【0032】

In the unit body 1a, the rotary valve 6a retains 1,000 μL of the diluent (a mixture of a dilution agent and a hemolyzing agent) preliminarily metered in the diluent container 5a. The inner cylinder 17a is initially in a rotational position as shown in FIGS. 16(a) and 16(b) with respect to the outer cylinder 16a, so that the diluent L is confined in the container 5a as shown in FIG. 21.

【0033】

The unit body 1a is connected to the analyzer 100a as shown in FIG. 12, and about 10 μL to about 150 μL of a whole blood sample B is injected into the sample receiving section 4a by a syringe or a pipette as shown in FIG. 21. Alternatively, the capillary blood sampler in which the whole blood sample is retained may be inserted into an inlet of the channel 11a. Then, the sealing member on the top of the outer cylinder 16a of the rotary valve 6a is removed to open the through-hole 37a. The sealing member may be removed by a user of the analyzer 100a or, alternatively, the sealing member may be pierced by a piercing needle

which may be provided in the analyzer 100a.

【0034】

When a start command is applied from the input section 107a (FIG. 12) (Step S1), the stepping motor 105a is driven so that the inner cylinder 17a is rotated clockwise by an angle $\theta 1$ from the position shown in FIGS. 16(a) and 16(b) (Steps S2 to S4) thereby to reach a position as shown in FIGS. 17(a), 17(b) and 22.

【0035】

Thus, the channels 11a, 12a communicate with each other via the lateral groove 25a to form the metering channel as shown in FIGS. 17(a) and 22. In this state, the syringe pump 102a performs a sucking operation for a time period T1 (Step S5 to S7), whereby the sample B flows into the channel 12a from the sample receiving section 4a via the lateral groove 25a to fill the lateral groove 25a as shown in FIG. 23.

【0036】

In turn, the stepping motor 105a is driven so that the inner cylinder 17a is rotated clockwise by an angle $\theta 2$ (Steps S8 to S10) thereby to reach a position as shown in FIGS. 18(a), 18(b) and 24. Thus, the sample is metered in a volume of 2μL which is equivalent to the volume of the lateral groove 25a, and separated by the inner circumferential surface of the outer cylinder 16a as shown in FIG. 24.

【0037】

At the same time, the channel 13a communicates with the bottom of the diluent container 5a via the lateral groove 26a, the vertical groove 32a and the through-hole 31a as shown in FIGS. 18(a) and 18(b).

【0038】

Then, the syringe pump 103a performs a sucking operation for a time period T2 (Steps S11 to S13), whereby the diluent L is introduced into the channels 13a, 14c from the diluent container 5a as shown in FIG. 25. In this state, the light emitting diode 125 is actuated, and the photodiode 126 measures the intensity of the light transmitted through the diluent (blank level) (Step S13a). When the syringe pump 103a performs a discharging operation for a time period T3 (Steps S13b to 13d), the diluent L is fed back into the diluent container 5a as shown in FIG. 26.

【0039】

Subsequently, the stepping motor 105a is driven so that the inner cylinder 17a is rotated by an angle θ 3 (Steps S14 to 16) thereby to reach a position as shown in FIGS. 19(a) and 19(b).

【0040】

Thus, the channel 13a communicates with the bottom of the diluent container 5a via the lateral groove 25a, the vertical groove 32a and the through-hole 30a to form the agitation channel as shown in FIGS. 19(a), 19(b) and 27. At the same time, the channel 11a communicates with the channel 12a via the lateral groove 24a as shown in FIG. 19(a).

【0041】

Then, the syringe pump 103a further performs the sucking operation for a time period T4 (Steps S17 to S19), whereby the diluent L in the diluent container 5a and the metered sample in the lateral groove 25a are introduced into the channel 13a as shown in FIG. 28.

【0042】

In turn, the syringe pump 103a performs a discharging operation for a time period T5 (Steps S20 to S22), whereby the sample and the diluent are fed back into the diluent container 5a as shown in FIG. 29.

【0043】

Subsequently, the syringe pump 103a repeats a T6-period sucking operation and a T7-period discharging operation N times, whereby the diluent and the sample flow back and forth between the channels 13a, 14c and the diluent container 5a in arrow directions A, B as shown in FIG. 30 (Steps S23 to S29). Thus, the diluent and the sample are sufficiently mixed and agitated for preparation of a 500-time diluted sample. The diluted sample is retained in the diluent container 5a as shown in FIG. 31.

【0044】

Then, the syringe pump 103a performs the sucking operation for a time period T8 (Steps S30 to S32), whereby the diluted sample is introduced into the channels 13a, 14c from the diluent container 5a as shown in FIG. 32. In this state, the photodiode 126 receives light emitted from the light emitting diode 125, whereby the intensity of the light transmitted through the diluted sample is measured (Step S32a).

【0045】

Subsequently, the syringe pump 103a performs the discharging operation for a time period T8a (Steps S32b to S32d), whereby the diluted sample is fed back into the diluent container 5a as shown in FIG. 33.

In turn, the syringe pump 104a performs a sucking operation for a time period T9, whereby the diluted sample flows toward the syringe pump 104a from the diluent container 5a via the pellet 33b and the channel 15g (i.e., via the measuring channel) as shown in FIG. 34. During this period, the signal processing section 106e measures an electrical resistance between the electrodes 34a and 35a (Steps S33 to S36).

【0046】

Then, the syringe pump 102a performs the sucking operation for a time period T10 (Steps S37 to S39), whereby all the sample remaining in the sample receiving section 4a is retained in the channel 12a as shown in FIG. 35. On the other hand, all the diluted sample in the diluent container 5a is retained in the channels 13a, 14c, 15g in Steps S33 to S36.

【0047】

In turn, the stepping motor 105a is driven so that the inner cylinder 17a is rotated clockwise by an angle $\theta 4$ (Steps S40 to S42) thereby to reach a position as shown in FIGS. 20(a) and 20(b). Thus, the channel 11a is brought out of communication with the channel 12a as shown in FIG. 36.

【0048】

In the aforesaid manner, the measuring operation is completed with the residual sample retained in the channel 12a and with the diluted sample retained in the channels 13a, 14c and 15g. After the through-hole 37a in the top wall of the rotary valve 6a is sealed again,

the unit body 1a is removed from the analyzer 100a and discarded (Step S43). Since the unit body 1a is discarded after use, a user can perform a sample analyzing operation safely and sanitarily.

【0049】

7. Analysis of White Blood Cells and Hemoglobin

When the constant current from the constant direct current source 101a (FIG. 12) is applied to the diluted sample between the electrodes 34a and 35a in a space separated by the pellet 33b having the minute through-hole 33c as shown in FIG. 10, the electrical resistance between the electrodes 34a and 35a generally depends on the specific resistivity of a liquid component of the diluted sample. Particularly, the electrical resistance is determined by an electrical resistance of the liquid component present in and around the minute through-hole 33c, mainly depending on the diameter and length of the minute through-hole 33c.

【0050】

When a white blood cell passes through the minute through-hole 33c, the liquid component is removed by the volume of the white blood cell, so that the electrical resistance between the electrodes 34a and 35a changes. A change in the electrical resistance is detected as a voltage pulse generated between the electrodes 34a and 35a.

Therefore, the computing section 106d determines the number of white blood cells on the basis of the number of pulses. Since the amplitude of the pulse is proportional to the volume of the white blood cell, the computing section 106d detects the amplitude of each pulse, and calculates the spherical equivalent diameter of each white blood

cell for preparation of a particle size distribution diagram.

Further, the computing section 106d determines the absorbance of the diluted sample by a known method on the basis of the transmitted light intensity of the diluent (blank level) and the transmitted light intensity of the diluted sample obtained by the optical characteristic measuring section 7b (FIG. 1). The amount of the hemoglobin is calculated on the basis of the absorbance thus determined.

【0051】

8. Construction of Pellet (Partition Member) 33b of Electrical Resistance Measuring Section

FIG. 39 is an enlarged view of the pellet 33b shown in FIG. 10.

As shown, the pellet 33b is a unitary member which includes a disk-shaped pellet base 33a having an outer diameter D1 and a thickness L1, and a ring-shaped projecting portion 33d projecting from an upper peripheral edge thereof and having a height L2 and a thickness L4. That is, the pellet 33b includes a pellet base 33a having the minute through-hole 33c, and a ring-shaped projecting portion 33d projecting axially of the minute through-hole 33c from the pellet base 33a as surrounding the minute through-hole 33c. The pellet base 33a has a round recess 33e formed in a center portion thereof and having a diameter D2 and a depth L3, and the through-hole 33c extending through the center thereof and having a diameter D3. The through-hole 33c has a length (L1-L3) which is 1.2 to 1.3 times the diameter D3.

In this embodiment, L1=0.3 mm, L2=1.4 mm, L3=0.17 mm, L4=1 mm, D1=6 mm, D2=1.1 mm, and D3=0.1 mm. A resin, which may be either a

thermoplastic resin or a thermosetting resin, is used as a material for the pellet 33b.

【0052】

The pellet 33b having the aforesaid construction has a greater thickness along its outer periphery by a thickness L2 of 1.4 mm due to the presence of the projecting portion 33d. As shown in FIG. 10, the round projection of the upper plate 2a is fitted in the round recess 33e and a space surrounded by the projecting portion 33d of the pellet 33b, and the pellet 33b is assuredly press-fitted in the round recess of the lower plate 3a. That is, the projecting portion 33d is sandwiched between the round projection of the upper plate 2a and the round recess of the lower plate 3a. Therefore, no adhesive is required. Further, the projecting portion 33d serves to enhance the flexural rigidity of the pellet base 33a, thereby preventing deformation of the pellet 33b which may otherwise occur in the press-fitting of the pellet 33b.

【0053】

Further, surface areas of the upper plate 2a and the lower plate 3a in contact with the pellet 33b are virtually increased due to the presence of the pellet base 33a and the projecting portion 33d, so that liquid tightness between the pellet 33b and the upper and lower plates 2a, 3a is improved. Therefore, all the liquid flowing from the vertical portion 15e to the vertical portion 15d through the pellet 33b passes through the through-hole 33c without bypassing the through-hole around the outer periphery of the pellet 33b (without leakage). The presence of the round recess 33e allows the pellet 33b to have a greater thickness L1, so

that the pellet 33b has an increased strength.

【0054】

FIGS. 40 to 45 illustrate variations of the pellet 33b shown in FIG. 39.

A pellet shown in FIG. 40 has substantially the same construction as the pellet 33b shown in FIG. 39, but has a ring-shaped projecting portion 33f projecting from a lower peripheral edge of the pellet base 33a.

A pellet shown in FIG. 41 has substantially the same construction as the pellet shown in FIG. 40, but has a thinner pellet base 33a without the recess 33e.

【0055】

A pellet shown in FIG. 42 has substantially the same construction as the pellet shown in FIG. 39, but has a thinner pellet base 33a without the recess 33e.

A pellet shown in FIG. 43 has substantially the same construction as the pellet shown in FIG. 40, but the projecting portion 33d is provided on a surface opposite to that of the pellet base 33a having the recess 33e.

【0056】

A pellet shown in FIG. 44 has substantially the same construction as the pellet shown in FIG. 39, except that the projecting portion 33d has smaller outer and inner diameters.

A pellet shown in FIG. 45 has substantially the same construction as the pellet shown in FIG. 42, except that the projecting portion 33d has outer and inner diameters progressively increasing toward its distal edge away from the pellet base 33a.

The pellets shown in FIGS. 40 to 45 provide the same functions and effects as the pellet 33b shown in FIG. 39.

【0057】

9. Apparatus and Method for Producing Pellet (Partition Member) 33b

FIGS. 46 and 47 are plan views respectively illustrating mating surfaces (contact surfaces) of male and female dies of a mold for use in injection molding of the pellet 33b. FIG. 48 is a sectional view for explaining a positional relationship between the male and female dies and the pellet 33b to be molded.

As shown in FIG. 48, a core pin 43 having a diameter of 0.1 mm extends vertically through the male die 41, and projects from the mating surface of the male die 41. A round projection 44 having a diameter of 4 mm (=D1-2L4) and a height of 1.4 mm (=L2) is provided coaxially with a projection end of the core pin 43 on the mating surface of the male die 41. A round projection 45 having a diameter of 1.1 mm (=D2) and a height of 0.17 mm (=L3) is provided coaxially with the projection end of the core pin 43 on the surface of the projection 44. The projection end of the core pin 43 has a length of 0.13 mm (=L1-L3) as measured from the surface of the projection 45.

【0058】

On the other hand, a recess (cavity) 46 having a diameter of 6 mm (=D1) and a depth of 1.7 mm (=L1+L2) is formed in the mating surface of the female die 42. Further, a degassing pin 47 having a diameter D4 of 5 mm extends vertically through the female die 42, and its end face is exposed to be flush with the bottom face of the recess 46. The degassing

pin 47 has a degassing hole (vent) extending centrally thereof. The degassing hole includes a hole 148 with a diameter D5 of 0.05 mm and a length of 1 mm, a hole 149 with a diameter D6 of 0.5 mm and a length of 9 mm, and a hole 150 with a diameter D7 of 1 mm and a length of 8 mm, which are arranged in this order from the upper side to the lower side and communicate with each other.

【0059】

As shown in FIG. 47, the mating surface of the female die 42 is formed with a ring-shaped first gate half 49 coaxial with the recess 46, four second gates 50 extending radially from the recess 46 and connected to the first gate half 49, a sprue 51, and two runner halves 52 connecting the sprue 51 to the first gate half 49.

【0060】

Correspondingly, as shown in FIG. 46, the mating surface of the male die 41 is formed with a ring-shaped first gate half 49a coaxial with the core pin 43, a sprue lock pin hole 51a, and two runner halves 52a connecting the sprue lock pin hole 51a to the first gate half 49a. As shown in FIG. 46, the male die 41 includes a sprue lock pin 53 inserted in the sprue lock pin hole 51a and eight ejector pins 54.

【0061】

The male die 41 and the female die 42 respectively having the aforesaid constructions are combined together with their mating surfaces in contact with each other, and clamped by means of a clamping jig not shown. At this time, the core pin 43 is opposed to the degassing pin 47, and the first gate half 49 and the first gate half 49a

are joined to define a tubular first gate. Further, the runner halves 52 and the runner halves 52a are joined to define tubular runners.

【0062】

A thermoplastic molding material is heated at 200 to 280.degree. C. by a heater not shown thereby to be fluidized. The fluidized molding material is injected into the recess (cavity) 46 through the sprue 51, the runners and the first and second gates at a pressure of about 50 to 150 MPa. Preferred examples of the molding material include ABS resins, POM resins, PP resins, acrylic resins and polycarbonate resins.

【0063】

During the injection, air (gas) present in the recess (cavity) 46 is expelled through the degassing holes 148, 149, 150 formed in the degassing pin 47. Therefore, the molding material is smoothly filled in the recess (cavity) 46 through the first and second gates without local stagnation thereof.

【0064】

After the injection is completed and the molding material is cooled to be solidified, the male die 41 and the female die 42 are separated by the claming jip, whereby the ejector pins 54 and the sprue lock pin 53 are projected from the mating surface of the male die 41. Thus, the resulting molded product is ejected. The pellet 33b shown in FIG. 39 is obtained by removing portions of the product molded in the second gates.

【0065】

In this embodiment, the mold having the male die 41 and the female

die 42 is adapted to mold the single pellet. However, the mold may be adapted for simultaneously molding a plurality of pellets (e.g., four pellets). In this case, the male die 41 includes a plurality of core pins 43 and a plurality of projections 44, 45, and the female die 42 includes a plurality of corresponding recesses (cavities) 46. Sprues, runners and gates for simultaneously supplying the molding material into the plurality of recesses 46 are provided in the mold. Although the thermoplastic resin is used as the molding material in this embodiment, a thermosetting resin may be employed for the molding of the pellet.

【0066】

【Effect of the Invention】

It is possible to provide a partition member with higher levels of dimensional accuracy and reproducibility, and to provide a measuring unit which ensures accurate particle analysis because mechanical strength of the partition member is improved efficiently by the rib around the through-hole.

【BRIEF DESCRIPTION OF THE DRAWINGS】

【FIG. 1】

This figure is a top plan view of a measuring unit according to an embodiment of the present invention.

【FIG. 2】

This figure is a front view of the measuring unit according to the embodiment.

【FIG. 3】

This figure is a perspective view illustrating the internal construction of the measuring unit according to the embodiment.

【FIG. 4】

This figure is a top plan view of a rotary valve of the measuring unit according to the embodiment.

【FIG. 5】

This figure is a front view of the rotary valve of the measuring unit according to the embodiment.

【FIG. 6】

This figure is a bottom view of the rotary valve of the measuring unit according to the embodiment.

【FIG. 7】

This figure is a sectional view of the rotary valve as seen in an arrow direction A-A in FIG. 5.

【FIG. 8】

This figure is a sectional view of the rotary valve as seen in an arrow direction B-B in FIG. 5.

【FIG. 9】

This figure is a sectional view of the rotary valve as seen in an arrow direction X-X in FIG. 4.

【FIG. 10】

This figure is a sectional view illustrating a major portion of an electrical resistance measuring section of the measuring unit according to the embodiment.

【FIG. 11】

This figure is a sectional view illustrating a modification of the rotary valve.

【FIG. 12】

This figure is a block diagram illustrating the construction of an analyzer according to the embodiment.

【FIG. 13】

This figure is a flow chart for explaining the operation of the analyzer according to the embodiment shown in FIG. 12.

【FIG. 14】

This figure is a flow chart for explaining the operation of the analyzer according to the embodiment shown in FIG. 12.

【FIG. 15】

This figure is a flow chart for explaining the operation of the analyzer according to the embodiment shown in FIG. 12.

【FIG. 16】

This figure is a diagram for explaining the operation of the rotary valve of the measuring unit according to the embodiment.

【FIG. 17】

This figure is a diagram for explaining the operation of the rotary valve of the measuring unit according to the embodiment.

【FIG. 18】

This figure is a diagram for explaining the operation of the rotary valve of the measuring unit according to the embodiment.

【FIG. 19】

This figure is a diagram for explaining the operation of the rotary valve of the measuring unit according to the embodiment.

【FIG. 20】

This figure is a diagram for explaining the operation of the rotary valve of the measuring unit according to the embodiment.

【FIG. 21】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 22】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 23】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 24】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 25】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 26】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 27】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 28】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 29】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 30】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 31】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 32】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 33】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 34】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 35】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 36】

This figure is a diagram for explaining the movement of a sample and a diluent in the measuring unit according to the embodiment.

【FIG. 37】

This figure is a sectional view illustrating a major portion of the measuring unit shown in FIG. 1.

【FIG. 38】

This figure is a sectional view illustrating a major portion of a channel of the measuring unit shown in FIG. 1.

【FIG. 39】

This figure is a sectional view illustrating a pellet according to the embodiment.

【FIG. 40】

This figure is a sectional view illustrating variations of the pellet of FIG. 39.

【FIG. 41】

This figure is a sectional view illustrating variations of the pellet of FIG. 39.

【FIG. 42】

This figure is a sectional view illustrating variations of the pellet of FIG. 39.

【FIG. 43】

This figure is a sectional view illustrating variations of the pellet of FIG. 39.

【FIG. 44】

This figure is a sectional view illustrating variations of the pellet of FIG. 39.

【FIG. 45】

This figure is a sectional view illustrating variations of the pellet of FIG. 39.

【FIG. 46】

This figure is a plan view of a male die of a mold according to the embodiment.

【FIG. 47】

This figure is a plan view of a female die of the mold according to the embodiment.

【FIG. 48】

This figure is a sectional view for explaining a positional relationship between the male die and the female die of the mold according to the embodiment.

【EXPLANATION OF THE NOTES】

1a unit body

2a upper plate

3a lower plate

4a sample receiving section

5a diluent container

6a rotary valve

7a electrical resistance measuring section

8a first pump connection ports

9a second pump connection ports

10a third pump connection ports

11a channel

12a channel

13a channel

14c channel

15d vertical portion

15e vertical portion

15f internal channel

15g channel

16a outer cylinder

17a inner cylinder

18a flange

19a projection

20a projection

21a groove

22a through-hole

23a through-hole

24a lateral groove

25a lateral groove

26a lateral groove

27a through-hole

28a through-hole

29a through-hole

30a through-hole

31a through-hole

32a vertical groove

33b pellet

33c minute through-hole

34a electrode

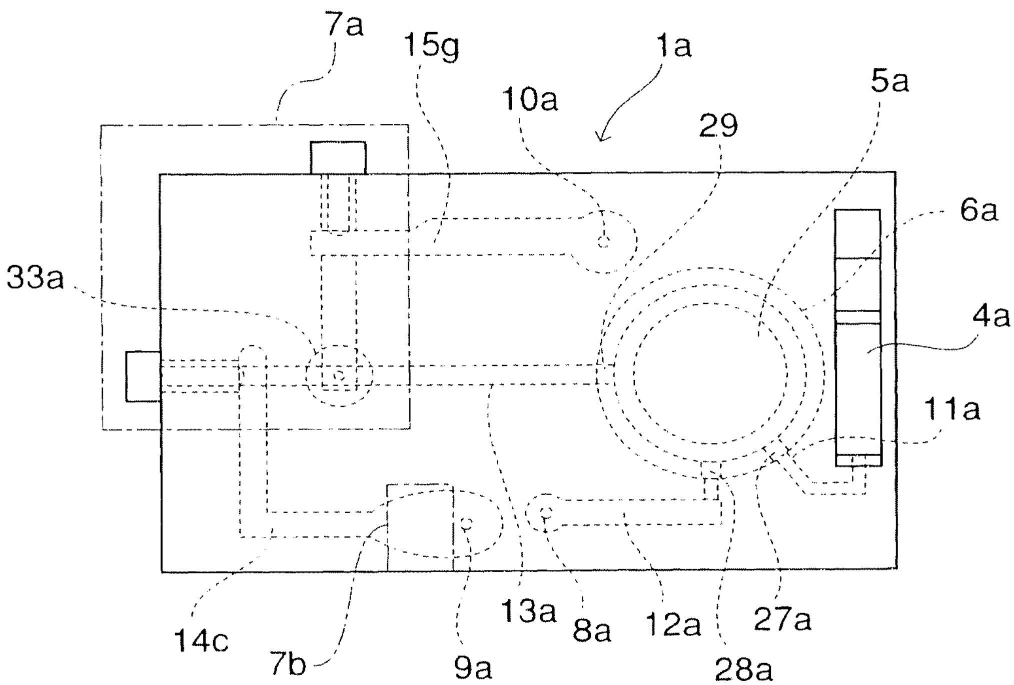
35a electrode

36a junction

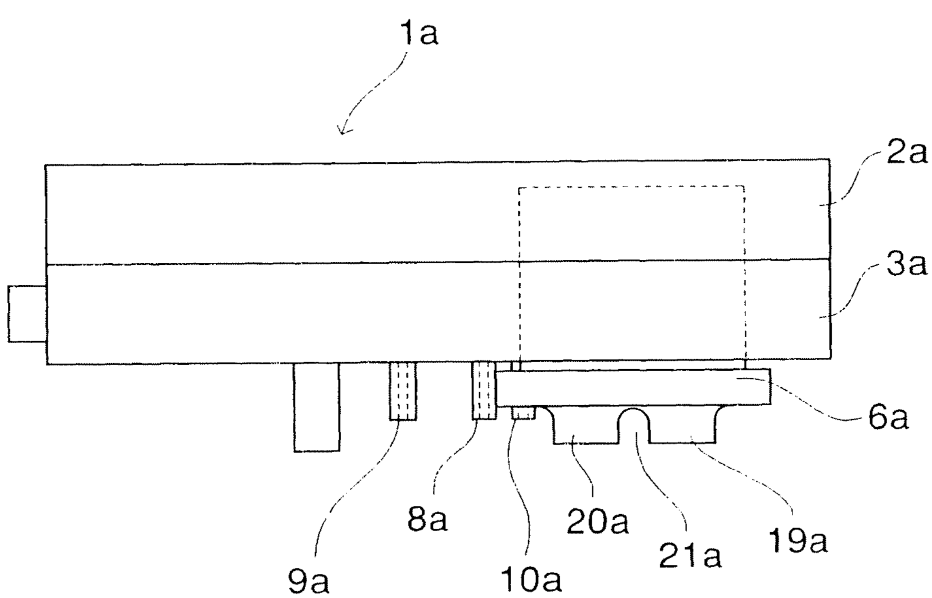
37a through-hole

【NAME OF THE DOCUMENT】 DRAWINGS

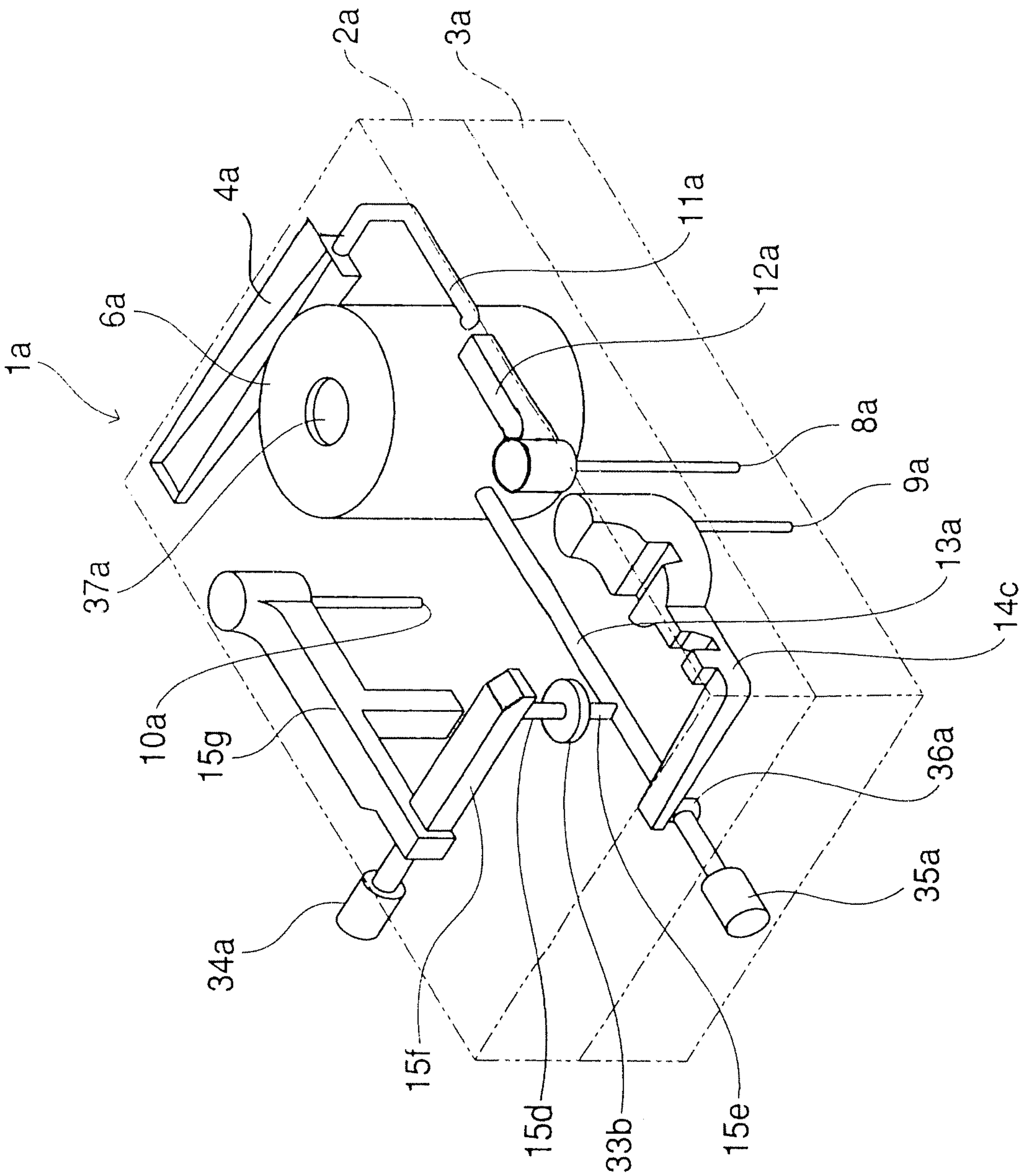
【FIG. 1】



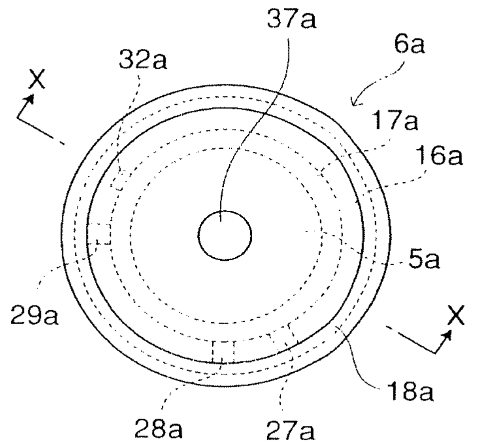
【FIG. 2】



【FIG. 3】

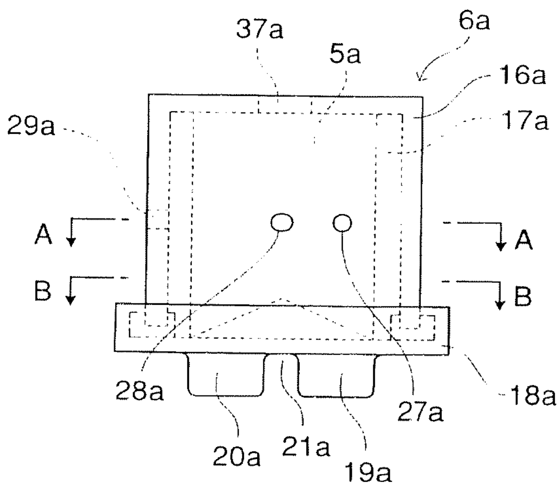

1a
2a
3a
4a
6a
37a
11a
12a
8a
9a
13a
14c
10a
15g
36a
35a
34a
15f
15d
33b
15e

【FIG. 4】



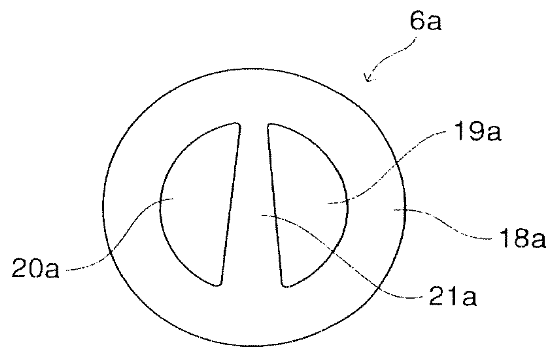
37a
6a
32a
X
17a
16a
5a
29a
X
18a
28a
27a

【FIG. 5】

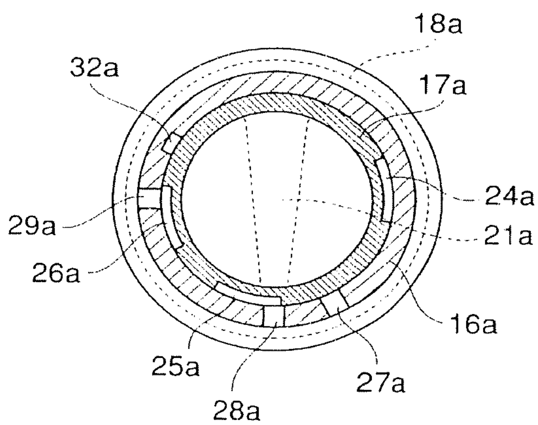


6a
37a
5a
16a
29a
17a
A
A
B
B
28a
27a
18a
20a
21a
19a

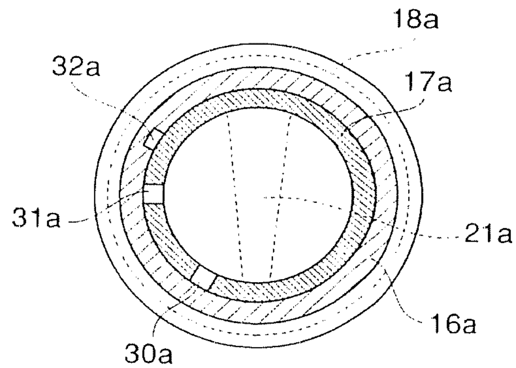
【FIG. 6】



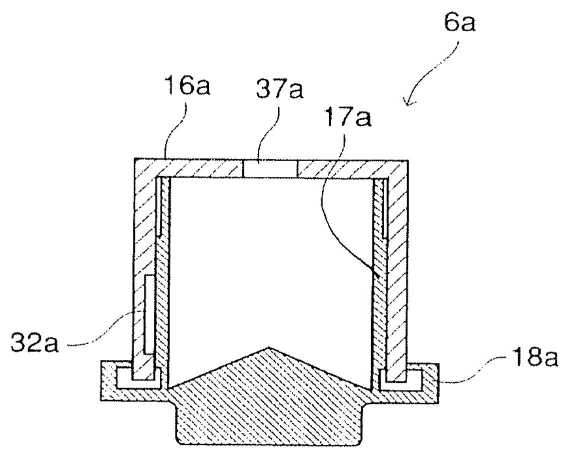
【FIG. 7】



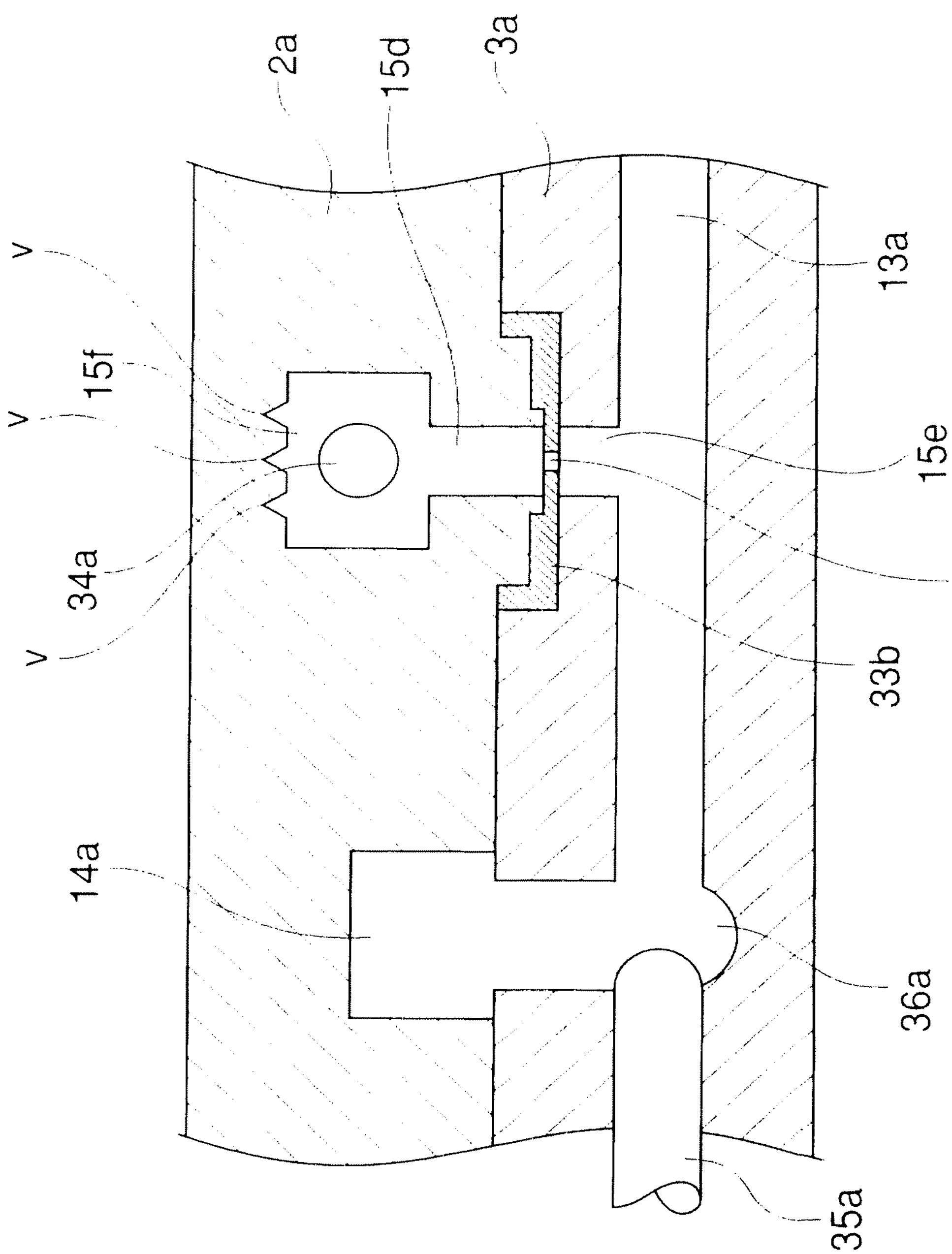
【FIG. 8】



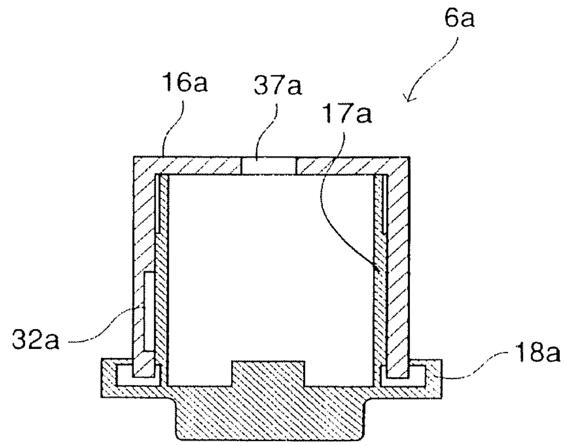
【FIG. 9】



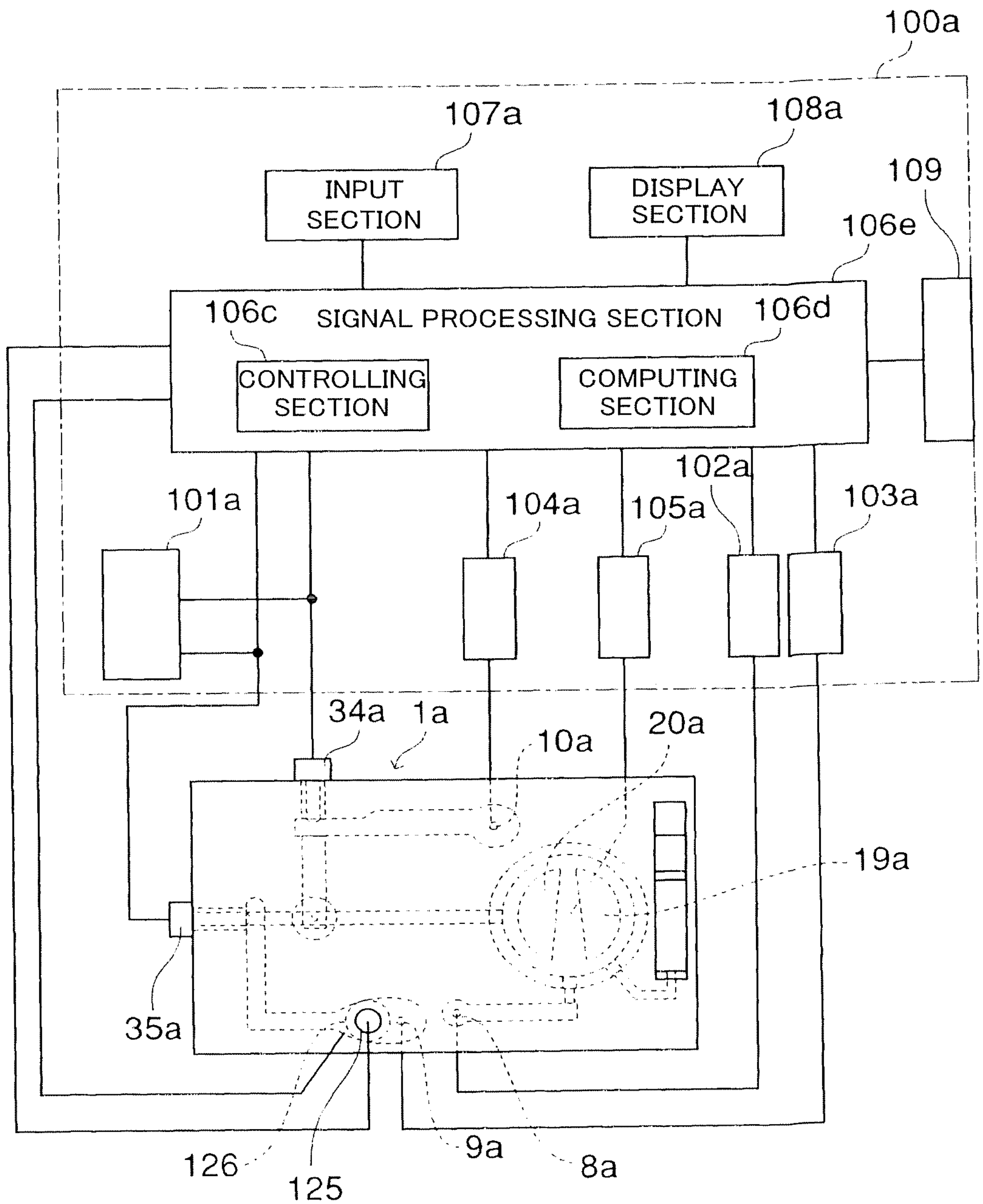
【FIG. 10】



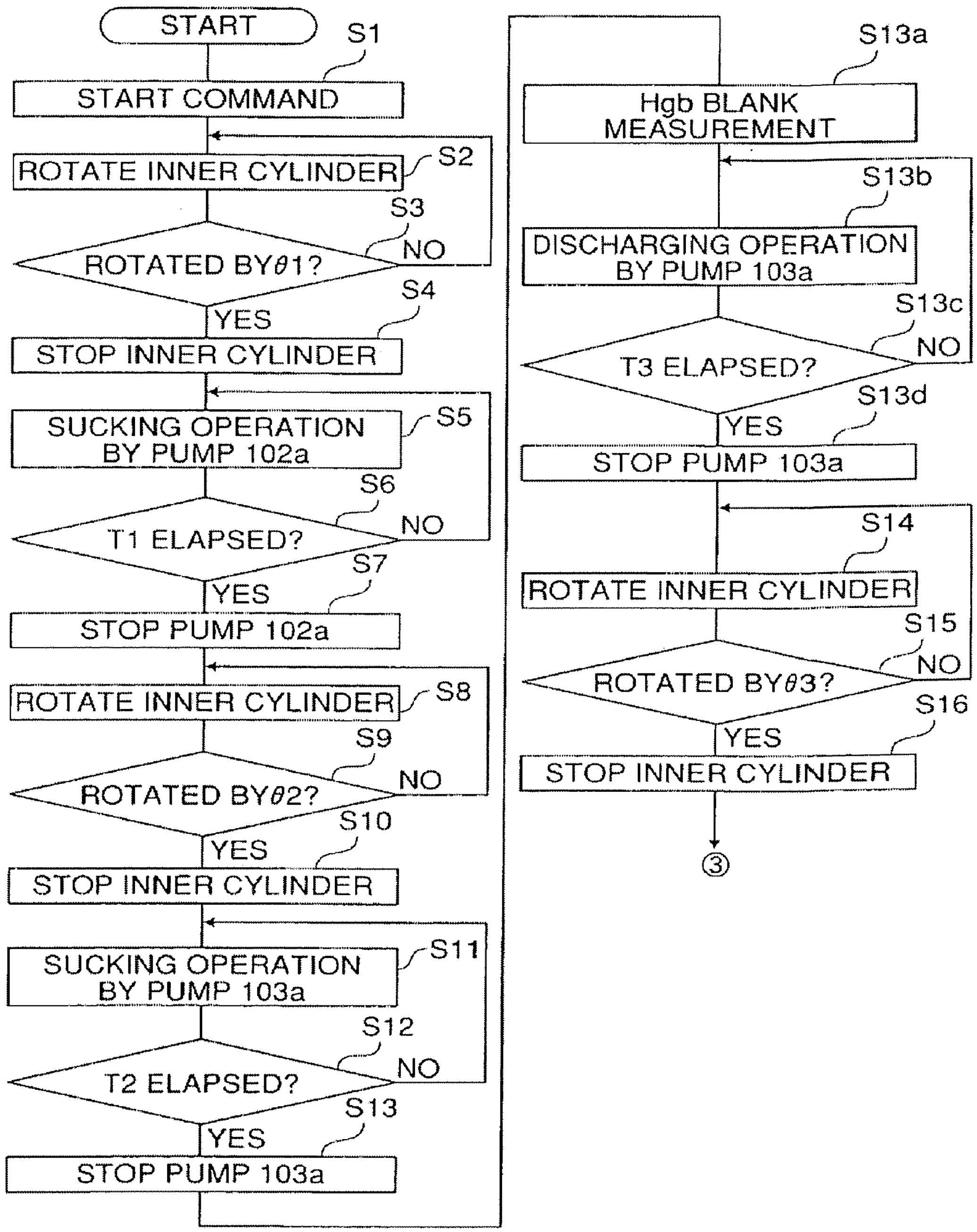
【FIG. 11】



【FIG. 12】

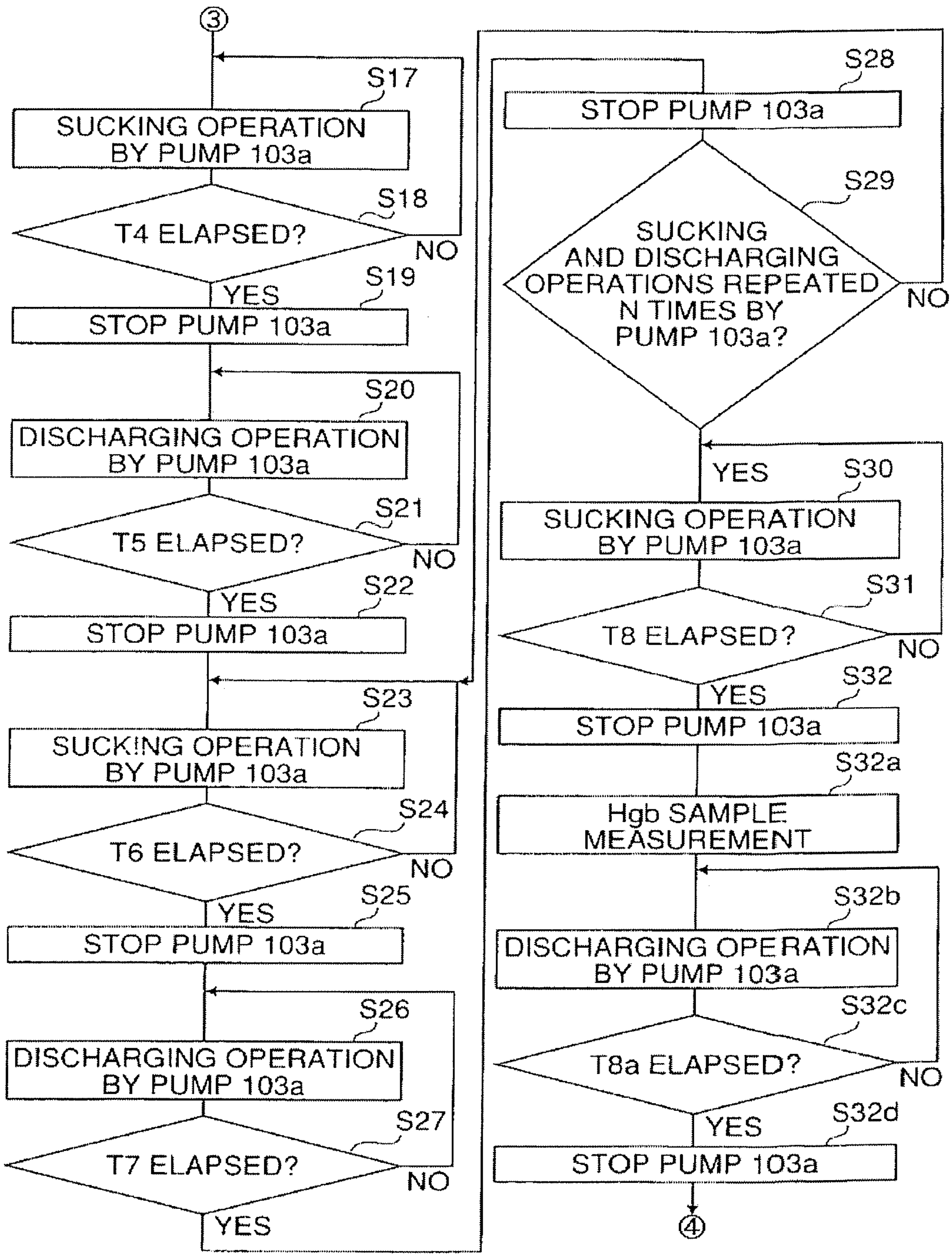

100a
107a
108a
INPUT SECTION
DISPLAY SECTION
109
106e
106c
SIGNAL PROCESSING SECTION
106d
CONTROLLING SECTION
COMPUTING SECTION
102a
101a
104a
105a
103a
34a
1a
10a
20a
19a
35a
126
125
9a
8a

【FIG. 13】



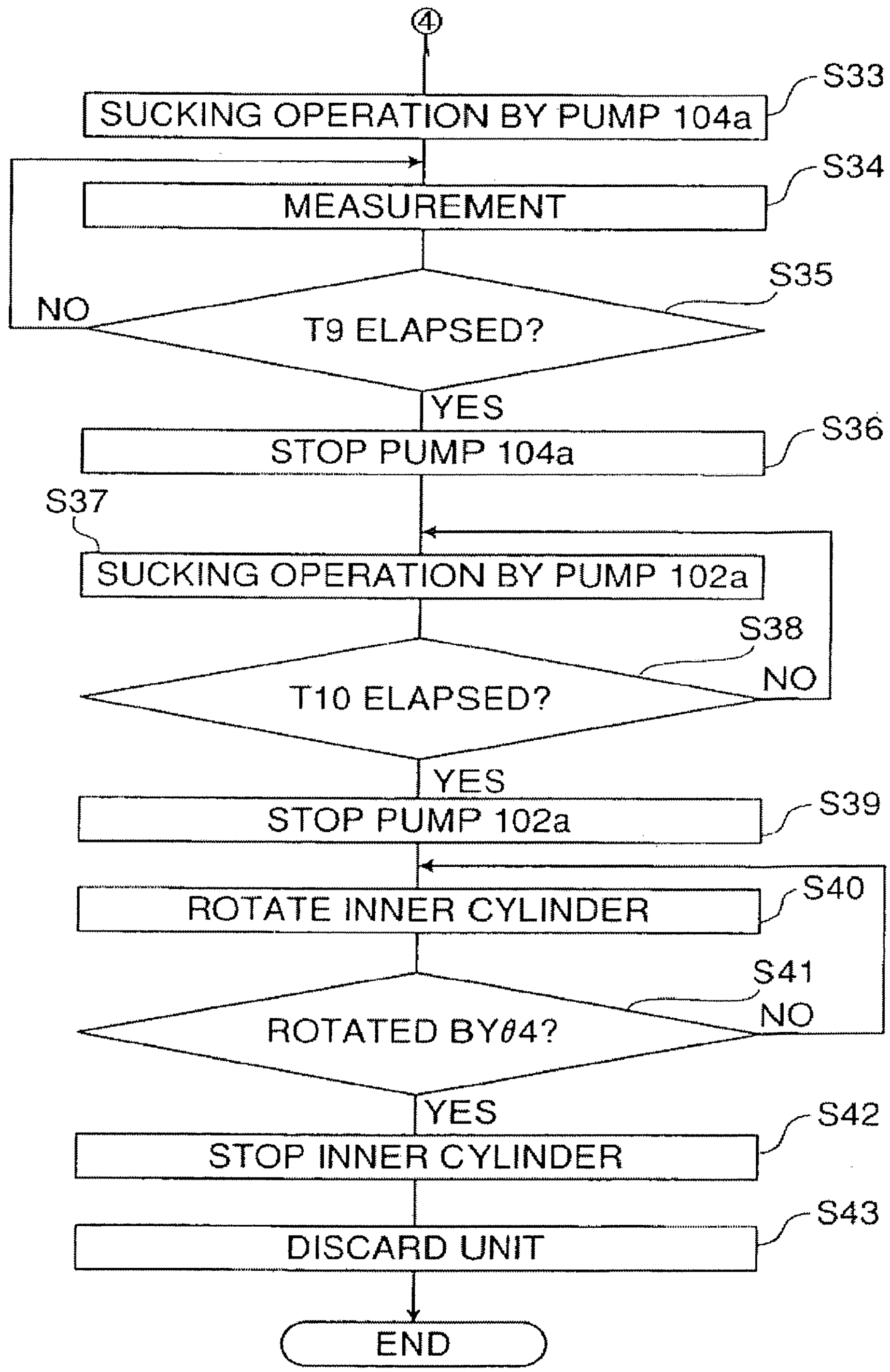
START
S1
START COMMAND
ROTATE INNER CYLINDER
S2
S3
ROTATED BYθ1?
NO
YES
S4
STOP INNER CYLINDER
SUCKING OPERATION BY PUMP 102a
S5
S6
T1 ELAPSED?
NO
YES
S7
STOP PUMP 102a
ROTATE INNER CYLINDER
S8
S9
ROTATED BYθ2?
NO
YES
S10
STOP INNER CYLINDER
SUCKING OPERATION BY PUMP 103a
S11
S12
T2 ELAPSED?
NO
YES
S13
STOP PUMP 103a
S13a
Hgb BLANK MEASUREMENT
S13b
DISCHARGING OPERATION BY PUMP 103a
S13c
T3 ELAPSED?
NO
YES
S13d
STOP PUMP 103a
S14
ROTATE INNER CYLINDER
S15
ROTATED BYθ3?
NO
YES
S16
STOP INNER CYLINDER
③

【FIG. 14】



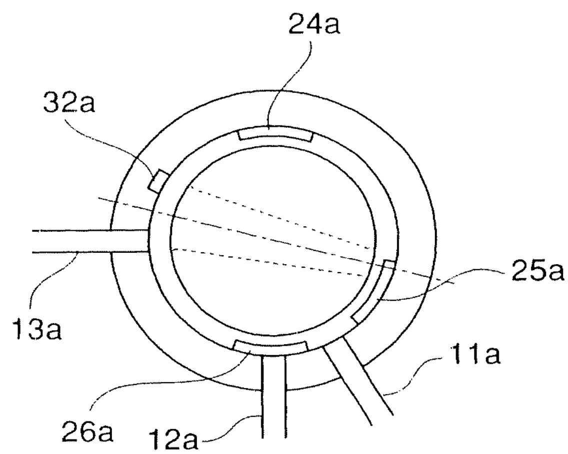
③
S17
SUCKING OPERATION BY PUMP 103a
S18
T4 ELAPSED?
NO
YES
S19
STOP PUMP 103a
S20
DISCHARGING OPERATION BY PUMP 103a
S21
T5 ELAPSED?
NO
YES
S22
STOP PUMP 103a
S23
SUCKING OPERATION BY PUMP 103a
S24
T6 ELAPSED?
NO
YES
S25
STOP PUMP 103a
S26
DISCHARGING OPERATION BY PUMP 103a
S27
T7 ELAPSED?
NO
YES
S28
STOP PUMP 103a
S29
SUCKING AND DISCHARGING OPERATIONS REPEATED N TIMES BY PUMP 103a?
NO
YES
S30
SUCKING OPERATION BY PUMP 103a
S31
T8 ELAPSED?
NO
YES
S32
STOP PUMP 103a
S32a
Hgb SAMPLE MEASUREMENT
S32b
DISCHARGING OPERATION BY PUMP 103a
S32c
T8a ELAPSED?
NO
YES
S32d
STOP PUMP 103a
④

【FIG. 15】

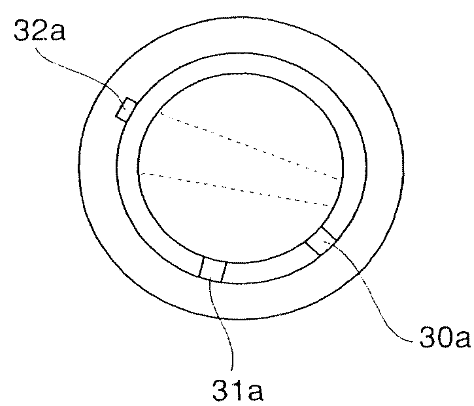

④
SUCKING OPERATION BY PUMP 104a
S33
MEASUREMENT
S34
T9 ELAPSED?
S35
NO
YES
STOP PUMP 104a
S36
S37
SUCKING OPERATION BY PUMP 102a
T10 ELAPSED?
S38
NO
YES
STOP PUMP 102a
S39
ROTATE INNER CYLINDER
S40
ROTATED BY θ4?
S41
NO
YES
STOP INNER CYLINDER
S42
DISCARD UNIT
S43
END

【FIG. 16】

(a)

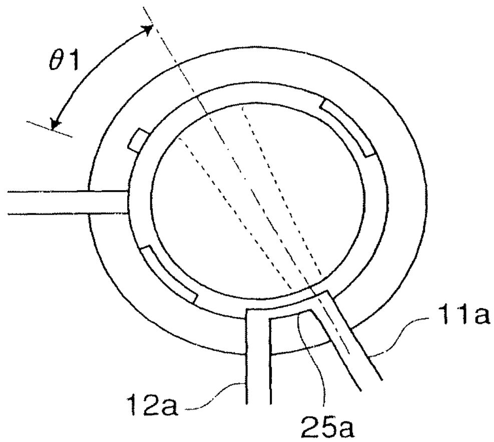


(b)

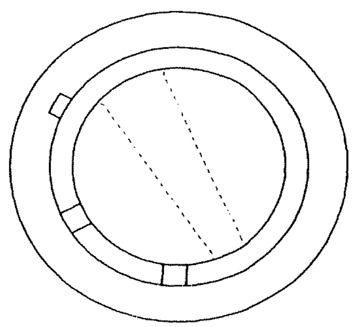


【FIG. 17】

(a)

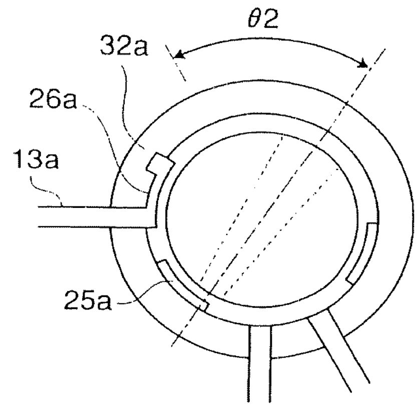


(b)

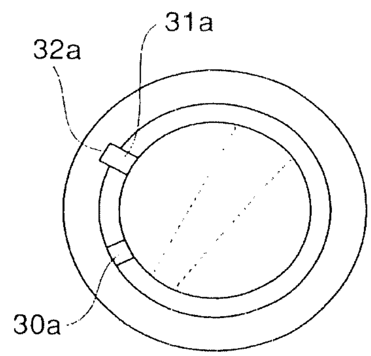


【FIG. 18】

(a)

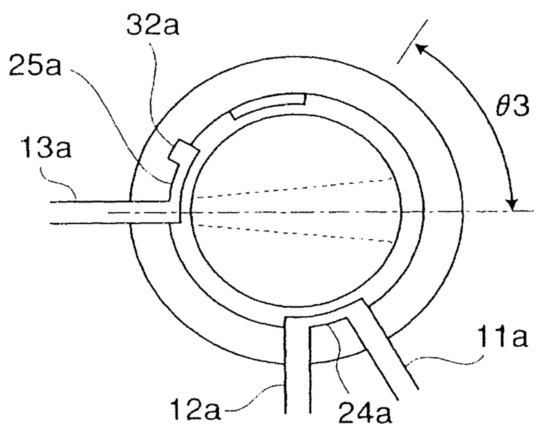


(b)

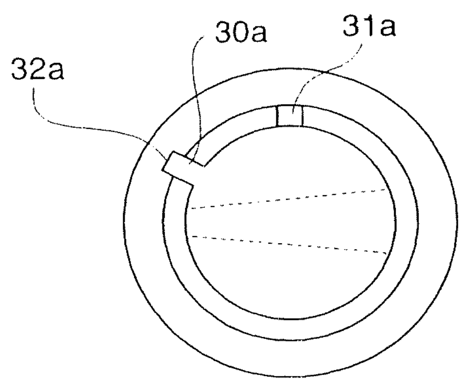


【FIG. 19】

(a)

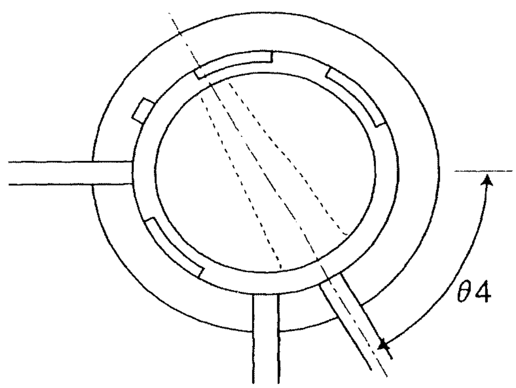


(b)

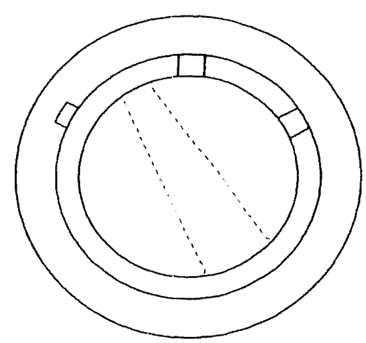


【FIG. 20】

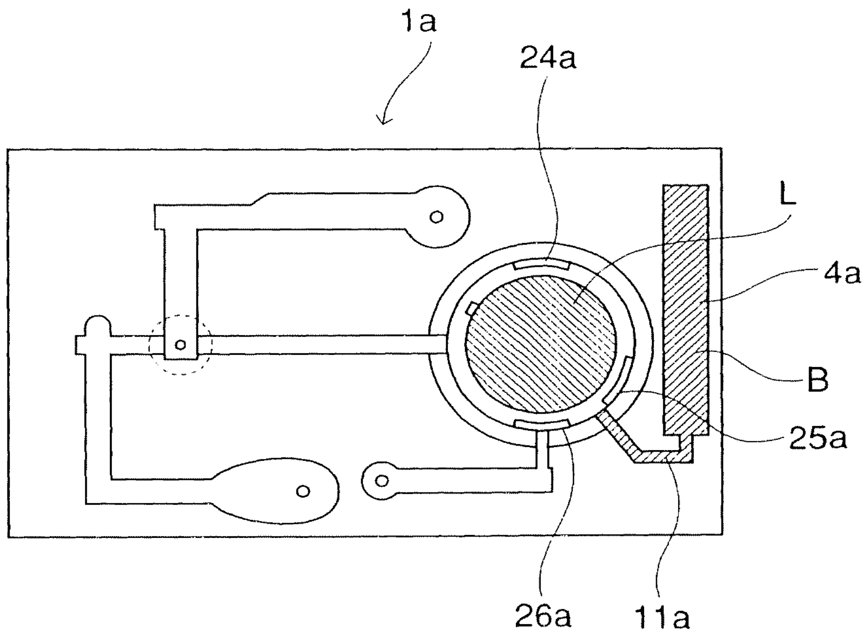
(a)



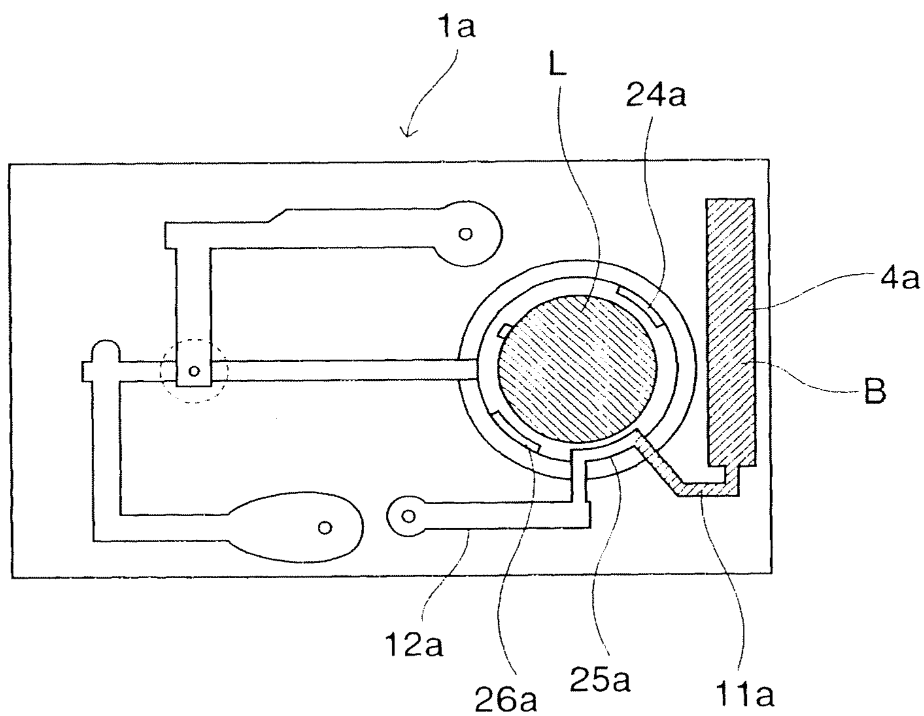
(b)



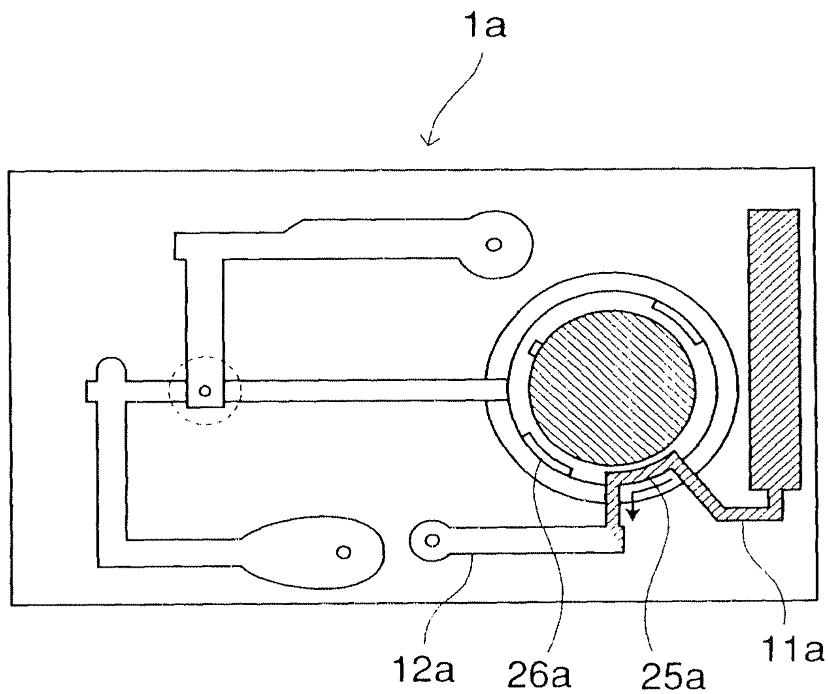
【FIG. 21】



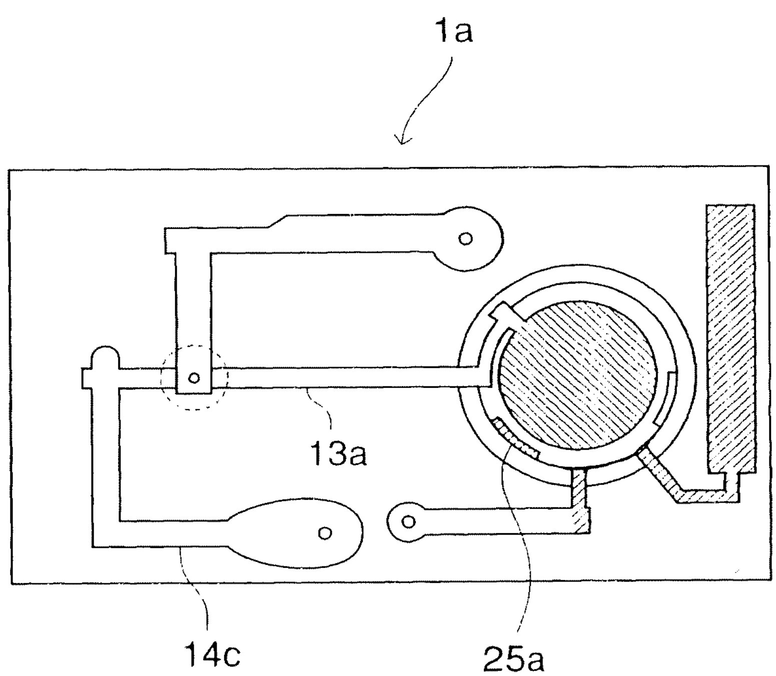
【FIG. 22】



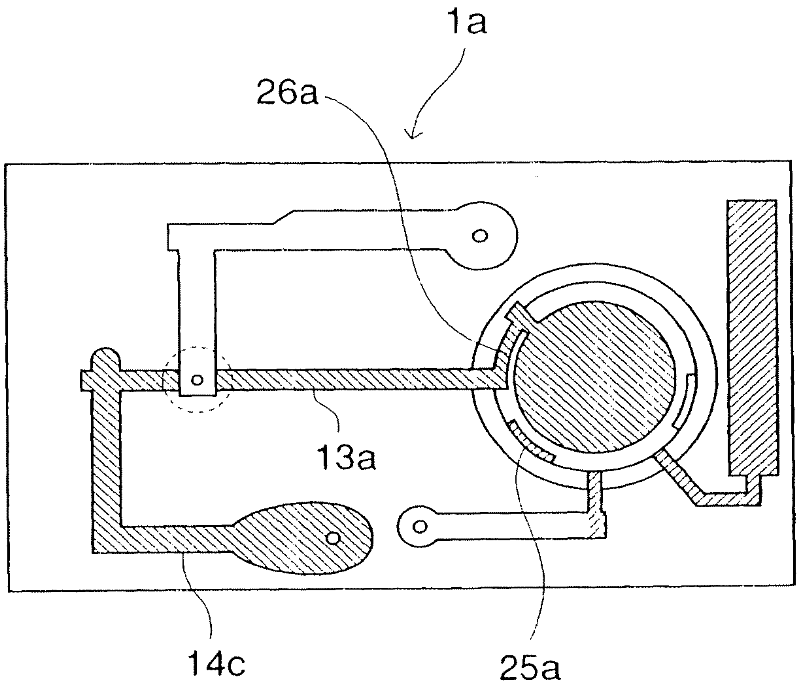
【FIG. 23】



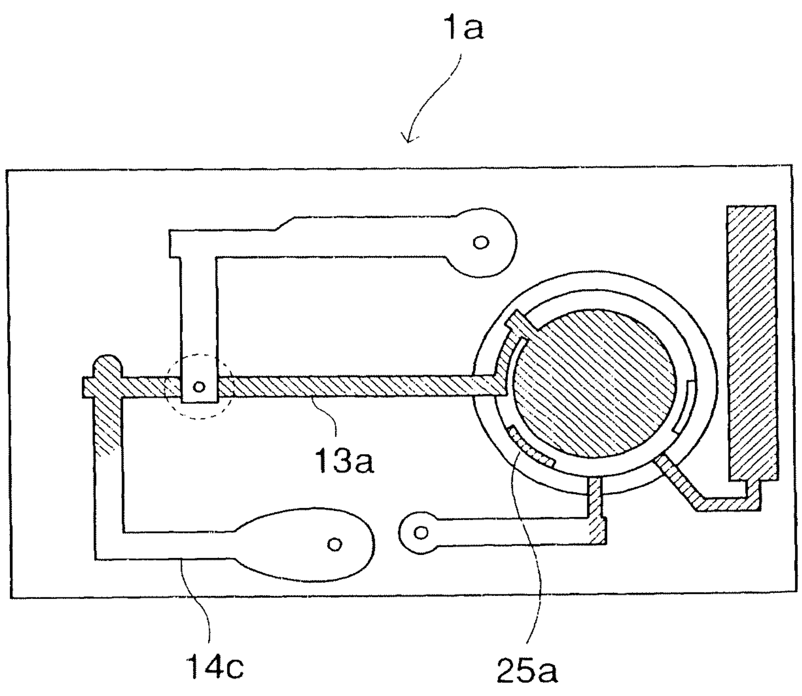
【FIG. 24】



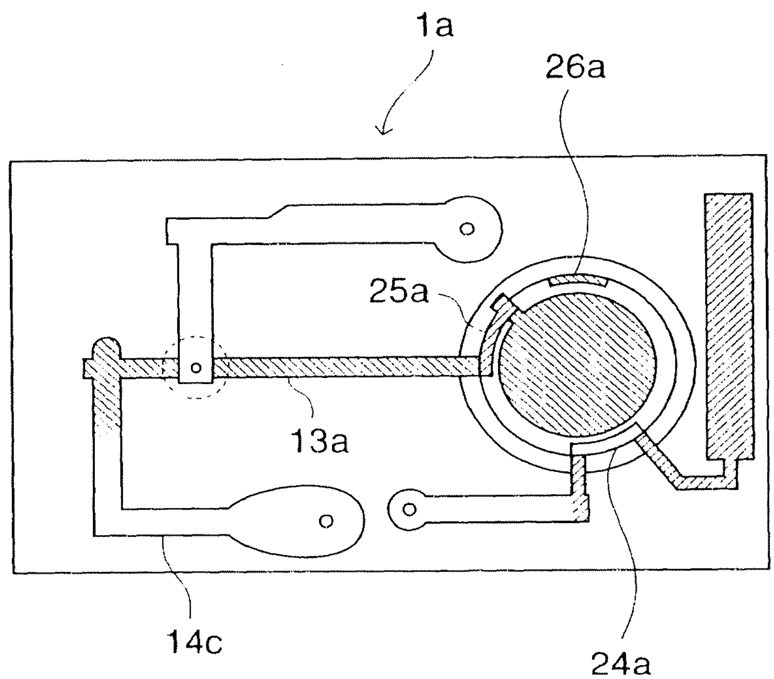
【FIG. 25】



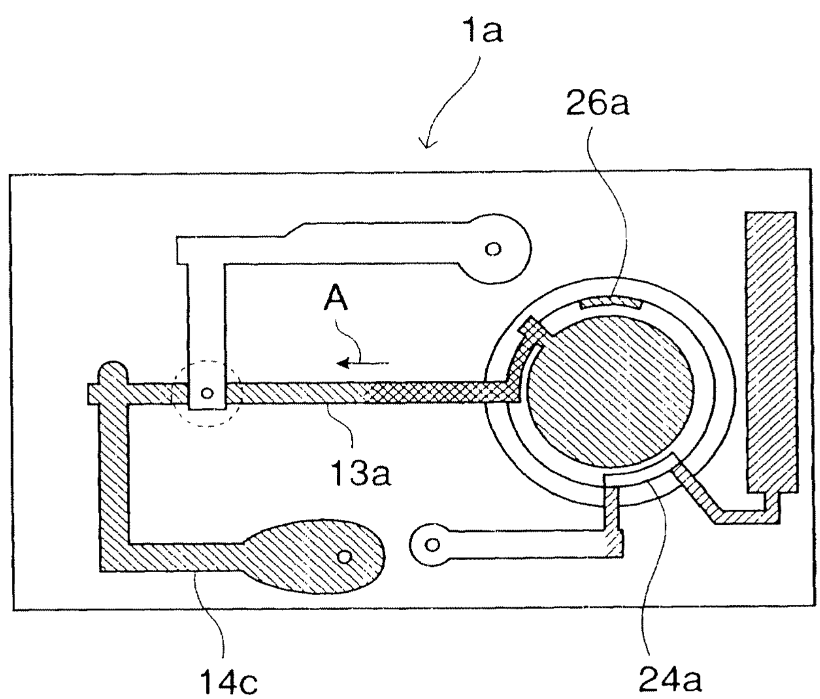
【FIG. 26】



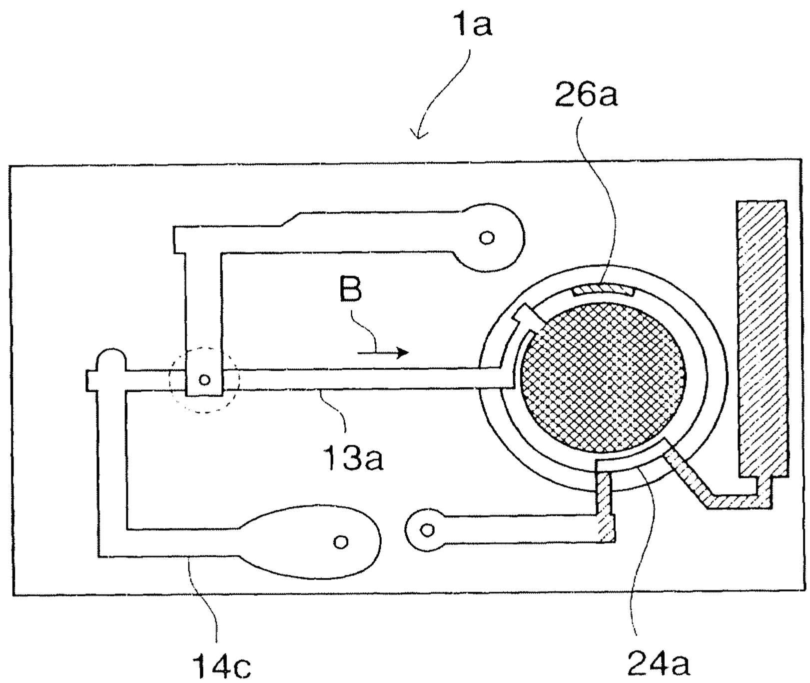
【FIG. 27】



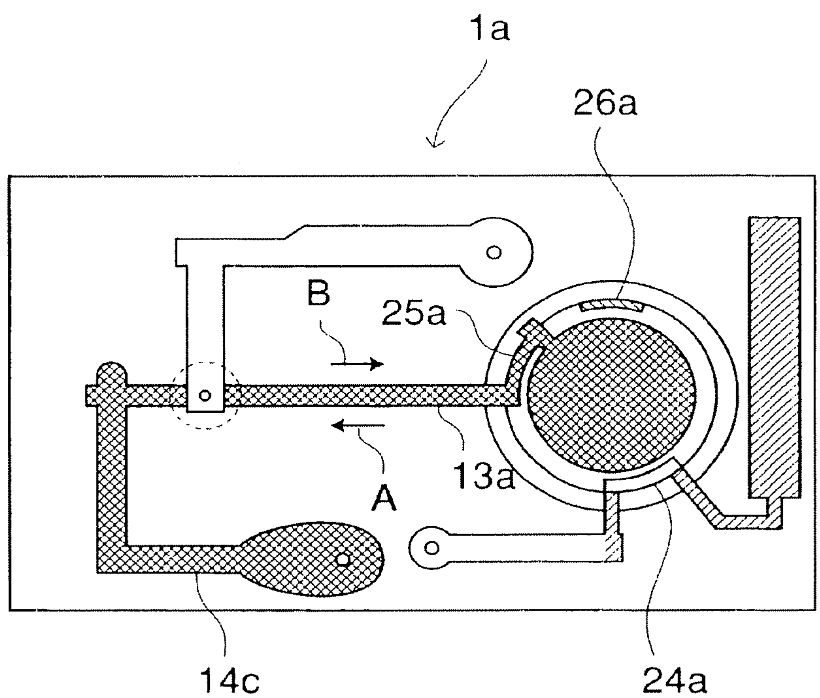
【FIG. 28】



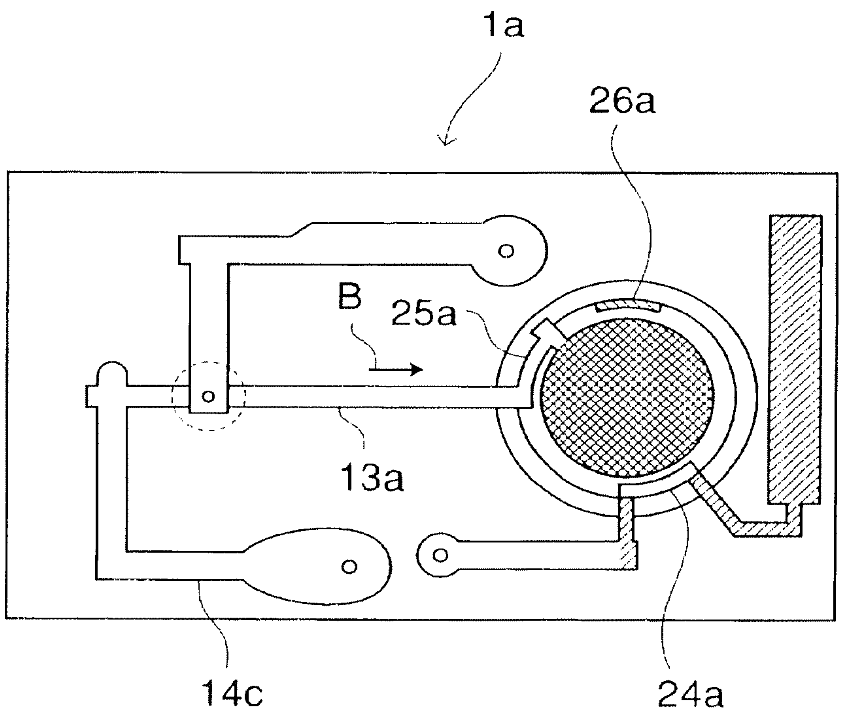
【FIG. 29】



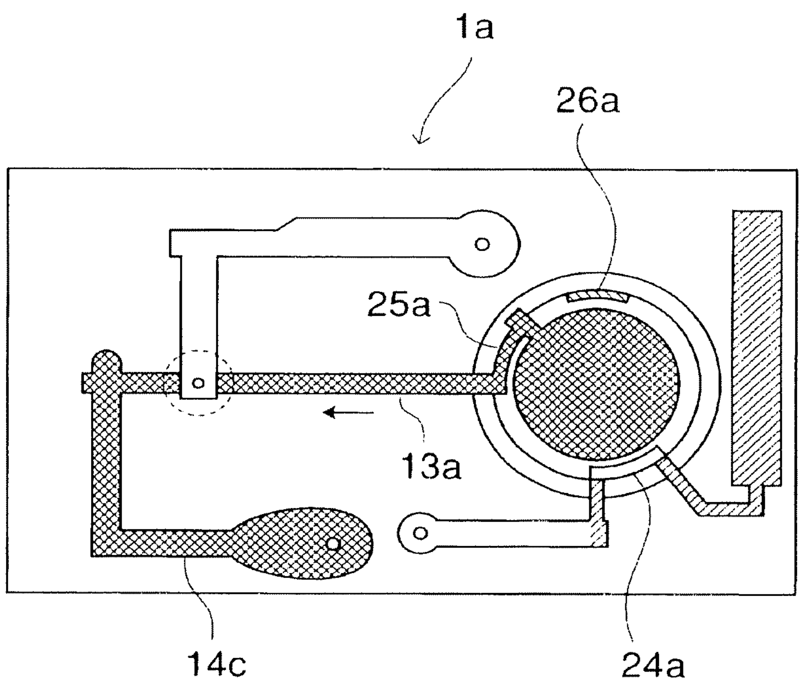
【FIG. 30】



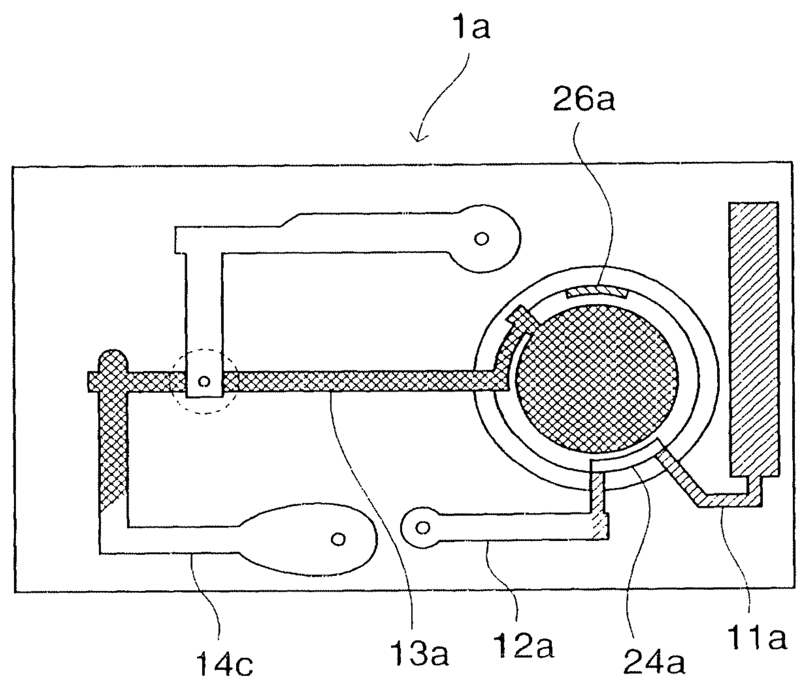
【FIG. 31】



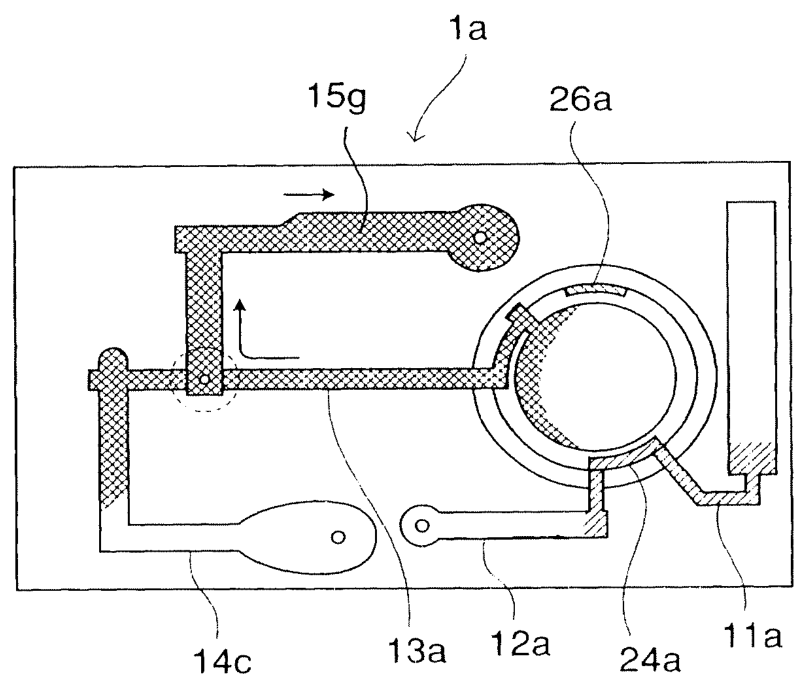
【FIG. 32】



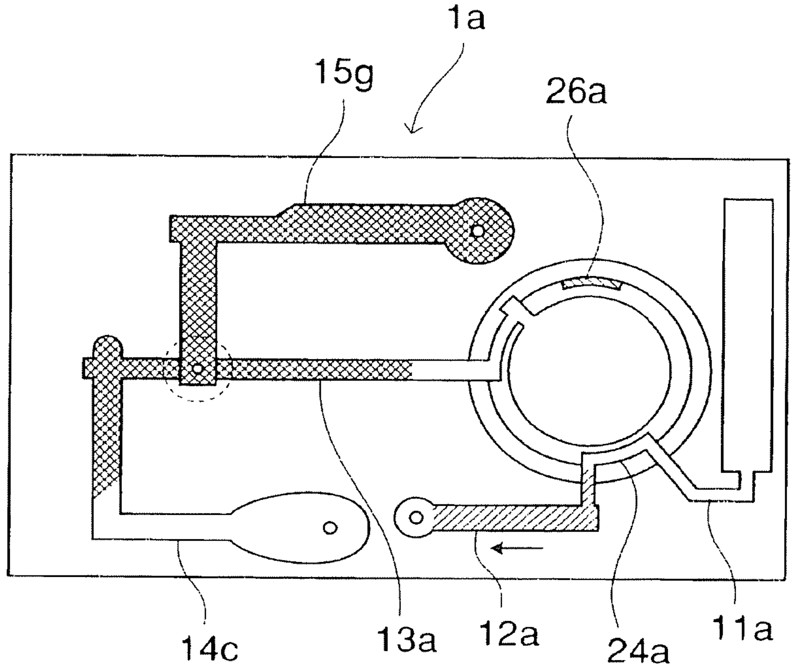
【FIG. 33】



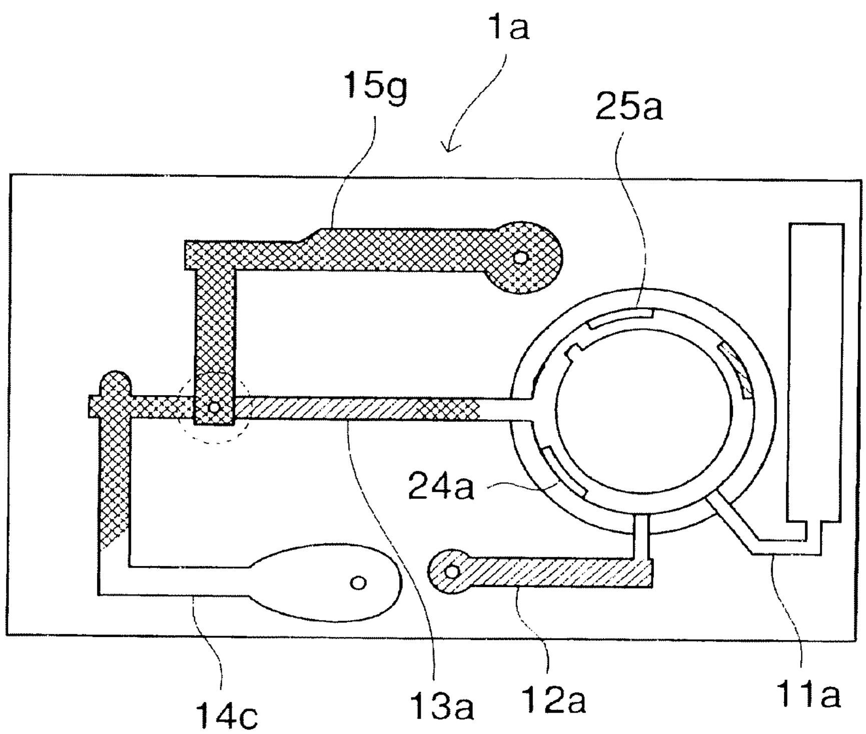
【FIG. 34】



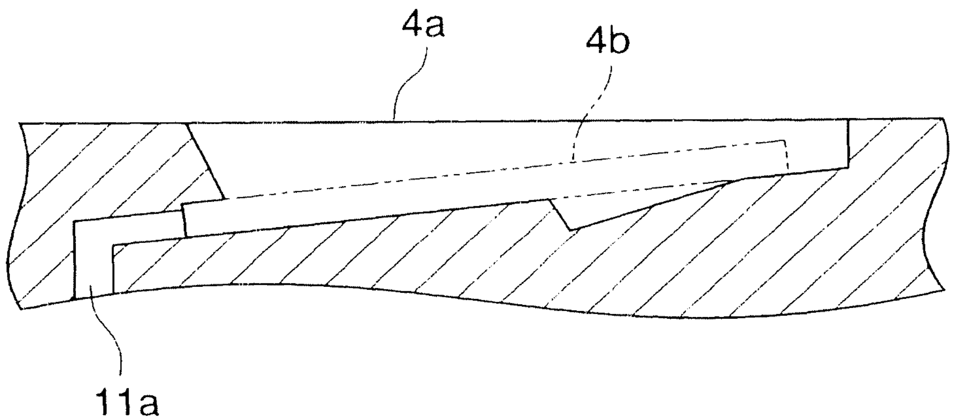
【FIG. 35】



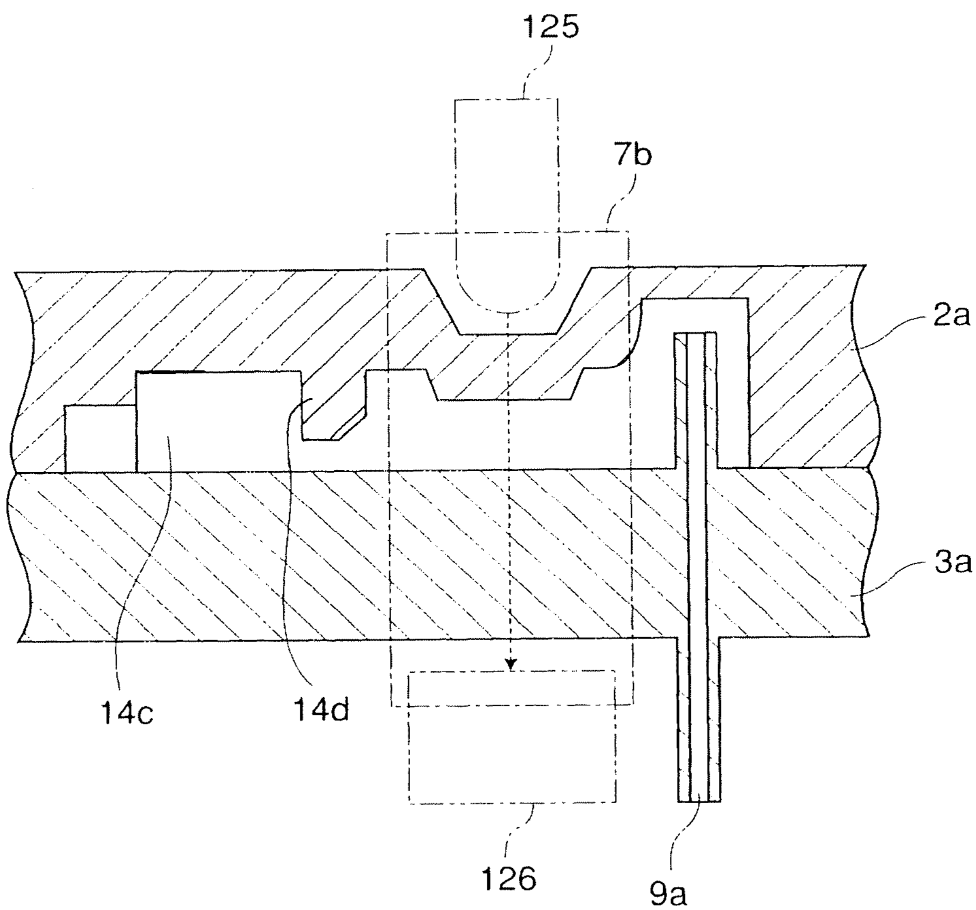
【FIG. 36】



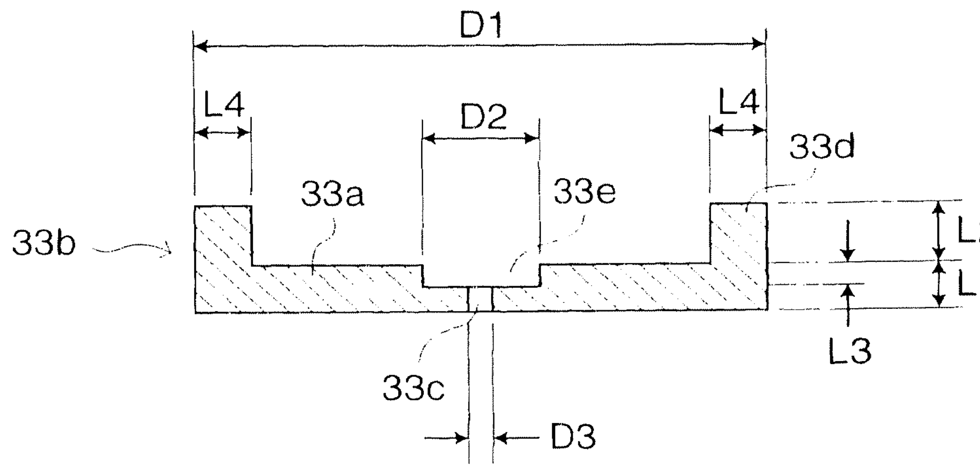
【FIG. 37】



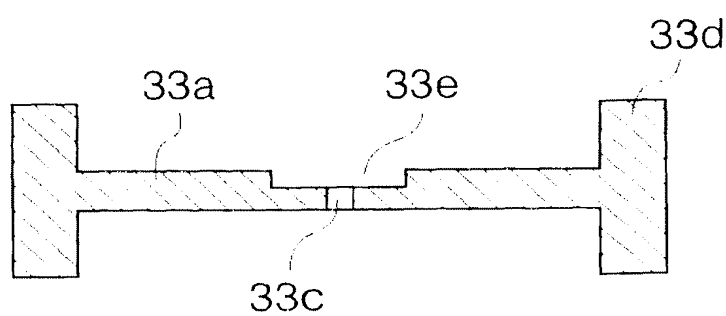
【FIG. 38】



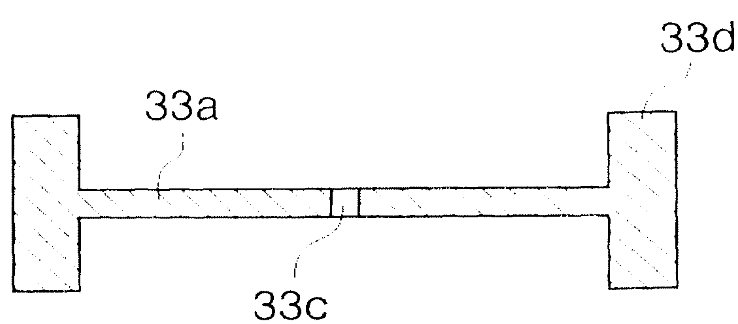
【FIG. 39】



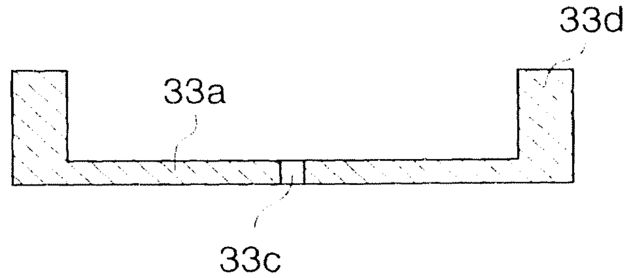
【FIG. 40】



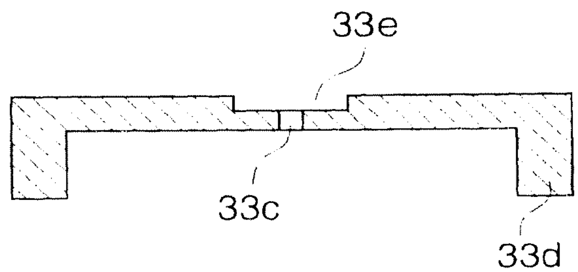
【FIG. 41】



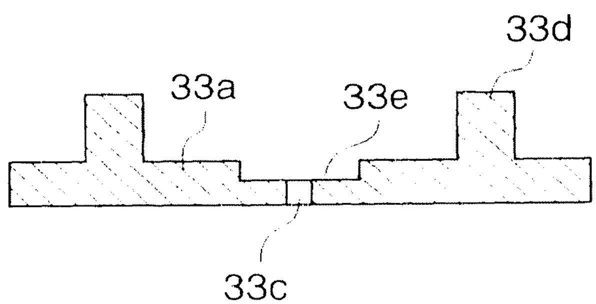
【FIG. 42】



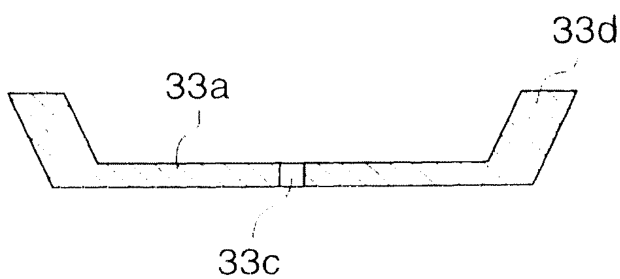
【FIG. 43】



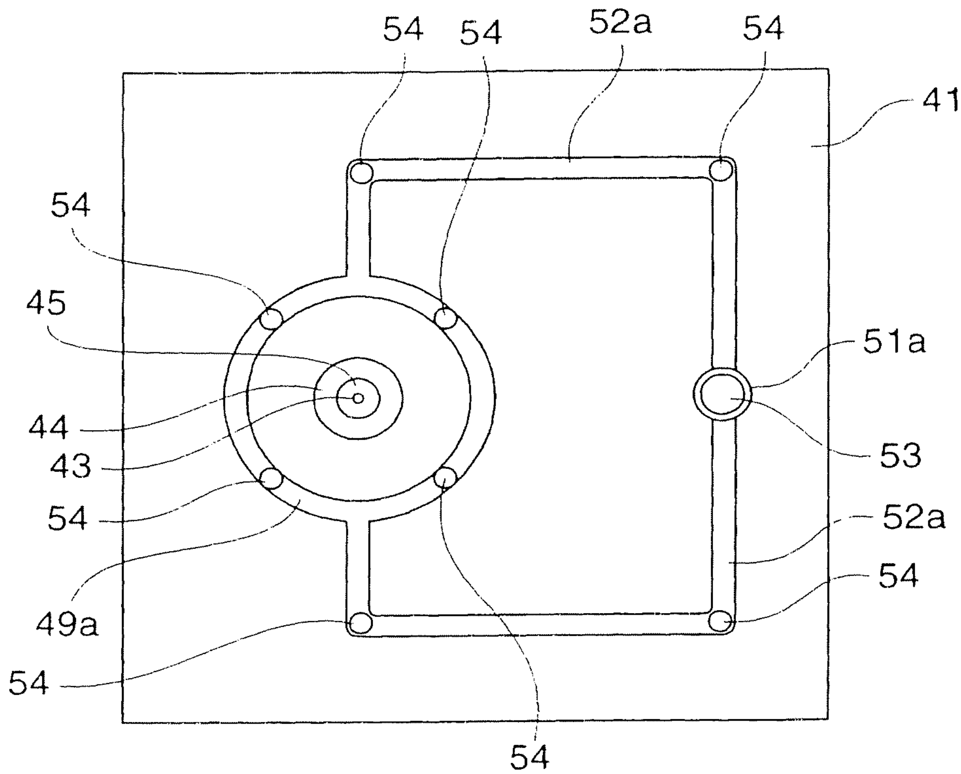
【FIG. 44】



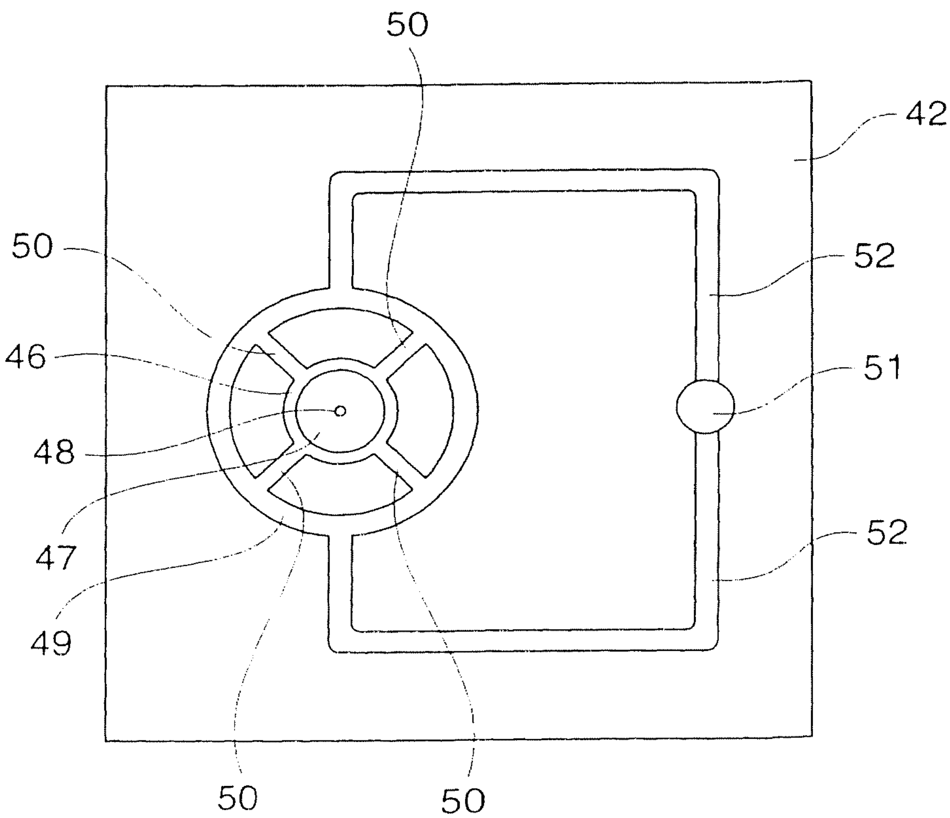
【FIG. 45】



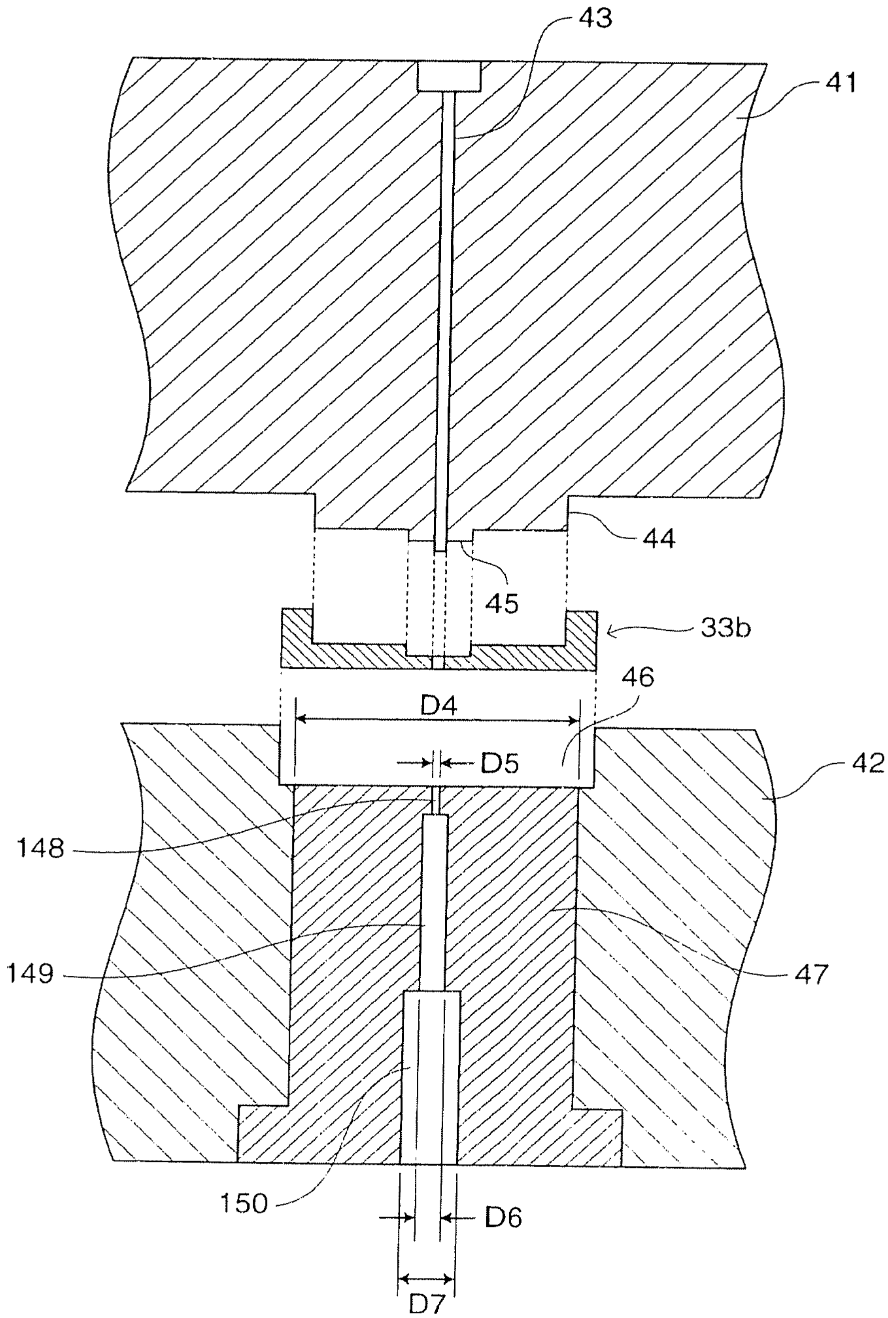
【FIG. 46】



【FIG. 47】



【FIG. 48】



【NAME OF THE DOCUMENT】 ABSTRACT

【ABSTRACT】

【PROBLEMS】 Providing a measuring unit which ensures accurate particle analysis by the electrical resistance method employing a partition member produced by softer material.

【MEANS FOR SOLVING THE PROBLEMS】 A measuring unit comprising: a partition member having a through-hole through which a liquid is allowed to pass and a rib which projects from at least either of a front surface and a rear surface around the through-hole; a first member having a first channel; and a second member having a second channel; wherein the partition member is sandwiched liquid tightly between the first member and the second member so that the through-hole allows the first member being communicated with the second member, and the first member and the second member respectively has a first electrode and a second electrode for measuring electrical properties of liquid passing via the through-hole in the first channel and the second channel.

【REPRESENTATIVE DRAWING】 FIG. 10